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EDITORIAL
Editor-in-Chief: Guy Cocker
Staff Writers: Christian Guyton, Sam Lewis
Contributing Writers: Jeremy Laird, Chris Lloyd, Ian Evenden, Jarred Walton, John Knight, Nick Peers, Matt Hanson
Production Editor: Jon Crampin
Editor Emeritus: Andrew Sanchez

ART
Art Editor: Fraser McDermott
Photography: Neil Godwin, Olly Curtis, Phil Barker
Cover Photo Credits: Future PLC

BUSINESS
US Marketing & Strategic Partnerships: Stacy Gaines, stacy.gaines@futurenet.com
US Chief Revenue Officer: Mike Peralta, mike.peralta@futurenet.com
East Coast Account Director: Brandie Rushing, brandie.rushing@futurenet.com
East Coast Account Director: Michael Plump, michael.plump@futurenet.com
East Coast Account Director: Victoria Sanders, victoria.sanders@futurenet.com
East Coast Account Director: Melissa Planty, melissa.planty@futurenet.com
East Coast Account Director: Elizabeth Fleischman, elizabeth.fleischman@futurenet.com
West Coast Account Director: Austin Park, austin.park@futurenet.com
West Coast Account Director: Jack McAuliffe, jack.mcauliffe@futurenet.com

Director, Client Services: Tracy Lam, tracy.lam@futurenet.com

MANAGEMENT
MD Tech Specialist: Keith Walker
Group Editor-in-Chief: Graham Barlow
Group Art Director: Jo Gulliver

PRODUCTION
Head of Production: Mark Constance
Senior Production Manager: Matthew Eglinton
Production Manager: Vivienne Calvert
Production Assistant: Emily Wood

FUTURE US, INC.
10th floor, 1100 13th Street, N.W Washington, DC 20005, USA
www.futureus.com

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Next Issue On Sale April 26th, 2022

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Guy
Cocker

NOT CONSOLING MYSELF

I STARTED my journalism career on a home theater publication, where I cut my teeth reviewing televisions, speakers, and amplifiers. So, when our writer Sam pitched the idea of building a living room PC for this issue, naturally, I said yes. The resulting build is stylish and compact but highly customizable, thanks to Intel's NUC 12 Extreme barebones PC. Sam built a machine that games, streams, and even works like a champ, while being easy to tuck away behind a TV or in an AV cabinet. You can follow his guide on page 16.

Sam's build highlights what a successful return to the living room the PC has made in the last couple of years. More televisions support Variable Refresh Rate standards from AMD and Nvidia, while GPUs and laptops are pushing HDMI 2.1 and 4K 120Hz output. I now regularly plug my PCs into my OLED TV for a quick gaming session, especially for controller-based games, such as *Forza Horizon 5* and *God of War*. For the first time ever, I now no longer even own an Xbox or PlayStation console. Living room PC gaming is just so much better.

On that note, we look forward to the best games coming our way this issue. There's been a lot of consolidation in gaming this year with Microsoft buying Activision and Sony buying Bungie, and as a result, we forget that there are loads of great games in development, including *Starfield*, *S.T.A.L.K.E.R. 2*, and *Saints Row*. We've rounded them up in our preview from page 36.

I know not all of you are into games, so elsewhere in this issue you'll also find a massive SSD roundup. Jeremy Laird has rounded up the best PCIe 4.0 M.2 drives available right now and declared a winner—you may be surprised who's victorious. Let's just say I'll be adding one such drive to the new Lenovo Legion 5i Pro I bought this month, so thanks for the recommendation, Jeremy!

Enjoy the issue!

Guy Cocker

Guy is Maximum PC's Editor-in-Chief. He built his first gaming PC in 1997 to play Tomb Raider on 3dfx, and has been obsessed with all things PC ever since.

↘ submit your questions to: editor@maximumpc.com

Statement of Ownership, Management, and Circulation, Required by United States Postal Service

1. Statement required by 39 U.S.C. 3685 showing the ownership, management, and circulation of *Maximum PC*
2. Publication no. 15224279
3. Date of filing: March 11, 2022
4. Issue frequency: Monthly with a holiday issue in December
5. Number of issues published annually: 13 issues
6: Annual subscription price: $46.95
7. Contact person: Mark Constance, +44 (0)1225 732206. Location of known office of publication: 130 West 42nd Street, 7th Floor, NY NY 10036-7804
8. Location of headquarters or general business offices of publisher: Same as above
9. The names and addresses of the Publisher and Editor-in-chief are: Publisher: Tim Clark, 130 West 42nd Street, 7th Floor, NY NY 10036-7804. Editor-in-chief: Guy Cocker, 130 West 42nd Street, 7th Floor, NY NY 10036-7804
10. The owner is: Future US INC (Future PLC), 130 West 42nd Street, 7th Floor, NY NY 10036-7804
11. For tax purposes, the purpose, function, and nonprofit status of this organization have not changed during the preceding 12 months
12. Publication title: *Maximum PC* magazine
13. Issue for circulation data below: 10/01/21

14. Extent and nature of circulation

	Average no. copies each issue during preceding 12 months	*No. copies of single issue published nearest to filing date*
a. Total Number of Copies	*36,287*	*35,174*
b. Paid and/or Requested Circulation		
(1) Paid/Requested Outside-County mail subscriptions stated on Form 3541	*18,434*	*17,224*
(2) Paid In-County subscriptions stated on Form 3541	*0*	*0*
(3) Sales through Dealers and Carriers, Street Vendors, Counter Sales, and Other Non-USPS Paid Distribution	*17,573*	*17,735*
(4) Other Classes mailed through the USPS	*0*	*0*
c. Total Paid and/or Requested Circulation	*36,007*	*34,959*
d. Free Distribution by Mail		
(1) Outside-County as stated on Form 3541	*275*	*210*
(2) In-County as stated on Form 3541	*0*	*0*
(3) Other Classes mailed through the USPS	*0*	*0*
(4) Free or Nominal Rate Distribution Outside the Mail	*5*	*5*
e. Total Free or Nominal Rate Distribution	*280*	*215*
f. Total Distribution	*36,287*	*35,174*
g. Copies not Distributed	*0*	*0*
h. Total	*36,287*	*35,174*
i. Percent Paid and/or Requested Circulation	*99.23%*	*99.39%*

15. I certify that the statements made by me above are correct and complete. (Signed) Tim Clark, Publisher

THE NEWS

AMD releases its 3D cache chip

A big cache, with big gaming performance claimed

BARELY A MONTH goes by without AMD or Intel releasing something juicy. This month, it's AMD's turn with the launch of the first chip to use its innovative 3D V-Cache technology. The new Ryzen 7 5800X3D is a regular Ryzen with a slab of extra cache stuck on top using a direct copper bond (technically, it's Through Silicon Vias (TSVs)—basically holes through the dies). The 5800X3D is an eight-core Zen 3 chip with a base clock of 3.4GHz and a maximum boost of 4.5GHz. It has 96MB of L3 cache, 64MB more than a 'regular' Ryzen 7 5800X. One side-effect is that the 5800X3D is AMD's first Ryzen that you can't overclock. The core voltage is locked at 1.35V, and there's no wriggle room to push it further.

At $449, the 5800X3D comes at a fair premium over a 5800X and is the same price as the Ryzen 9 5900X. That has 12 cores, a base clock of 3.7GHz, and a maximum boost of 4.8GHz. It also has 64MB of L3 cache, so it's not obvious on paper which chip is better. If games are your primary concern, then AMD says you need the 5800X3D and pits the two chips against each other in a selection of games. It says *Far Cry 6* runs "up to 24 percent" faster, *Final Fantasy XIV* manages 16 percent, and *Shadow of the Tomb Raider* nine percent. Overall, the Ryzen 7 5800X3D is claimed to run games at an average of 15 percent faster than the Ryzen 9 5900X at 1080p—the equivalent of a generation of core architecture in one go. This would also make it faster than an Intel Core i9-12900K, a clear target for this processor.

For gaming rigs, the 5800X3D is a clear winner. AMD says the benefits of the cache show in games, rather than synthetic tests. One early benchmark using Geekbench 5 proves this. The 5800X3D rates almost the same score on single-thread performance as a regular 5800X and has a nine percent hike in a multi-threaded benchmark, where the extra cache gets work to do.

AMD is singing the praises of its new silicon, saying the Ryzen 7 5800X3D is "the world's fastest gaming CPU". It officially goes on sale in April, so we shall see how it performs in a coming issue.

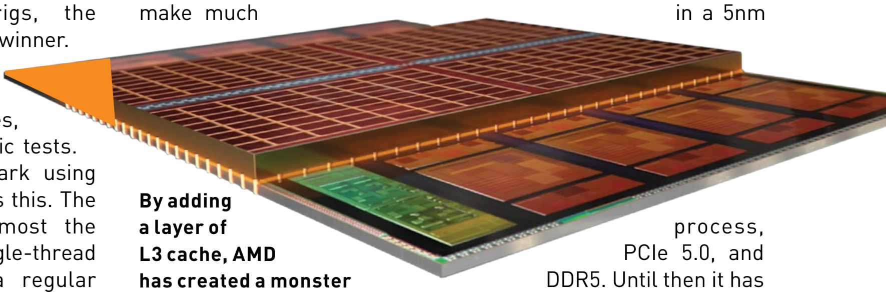
AMD has also released six new versions of existing designs, all with 65W TDP. There are three more Zen 3 chips: a Ryzen 7 5700X, which offers eight cores, a base clock of 3.4GHz, a maximum boost of 4.6GHz ($299). Then two six-core chips—Ryzen 5 5600 with a base clock of 3.5GHz, a maximum boost of 4.4GHz ($199), effectively a cheaper version of the Ryzen 5 5600X. Below this is the similar Ryzen 5 5500, with a base clock of 3.6GHz and a maximum boost of 4.2GHz. What you lose is half the L3 cache of the 5600 at 16MB, and the PCIe drops to version 3.0, which won't make much difference ($159). There are three new low-cost Zen 2 chips: the Ryzen 5 4600G, another six-core chip with integrated Radeon graphics engine ($154). Below this is a six-core Ryzen 5 4500 ($129) and the four-core Ryzen 3 4100 ($99). AMD has also added Zen 3 chip support to the 300-series motherboards, thanks to a new BIOS update, so you can move to a more modern CPU without switching boards.

AMD now has Zen 3 processors for under $300, whereas it previously had nothing below the Ryzen 5 5600X. The impetus for this is the competition. Alder Lake has given Intel a top-notch processor and reclaimed some of the ground it lost since AMD found its mojo with the Zen architecture.

AMD's real response to Alder Lake, and the upcoming Raptor Lake will be Zen 4, due later this year. This will bring in a 5nm process, PCIe 5.0, and DDR5. Until then it has to use prices and shuffle specs around to stay competitive.

The V-Cache idea is an oddity. Cache is always good, but gaming aside, it seems an expensive way to improve things. Where AMD takes it next should prove interesting. Is it just a sidebar to the real action, or will it become a more permanent fixture in AMD's line-up?

One of the company's managers let slip that future versions of V-Cache chips will be unlocked, so it looks as if the technique will be returning. For now, it has brought us the gaming chip of the moment, which is no bad thing. **–CL**



By adding a layer of L3 cache, AMD has created a monster gaming chip in the 5800X3D.

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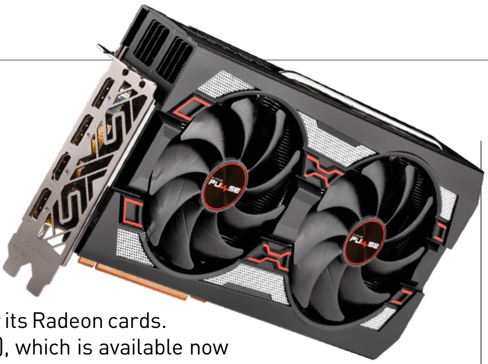

RADEONS GET RSR & FSR 2.0 THIS YEAR

AMD HAS A PAIR OF DRIVER UPDATES for its Radeon cards. First is RSR (Radeon Super Resolution), which is available now (driver version 22.3.1). It enables a wider range of games to use upscaling with FSR (Fidelity FX Super Resolution) and is supported on all Radeon RX 5000 series cards (it needs an RDNA-based GPU). You won't get the full FSR effect but you do get a healthy jump in speed. AMD claims RSR will give between two to three times the frame rate when you upscale 1080p to 4K. However, the results are better if you step up from 1440p or more. This summer, we'll also get FSR 2.0. The original FSR uses spacial upscaling (each frame is re-rendered in one pass), whereas version 2.0 introduces a temporal element (it uses data from multiple frames). The result is that more fine detail is preserved, giving a "near-native quality". All without any 'deep learning' AI too. These two performance upgrades are most welcome, given the current difficulties. **–CL**

STADIA GOES ENTERPRISE

Streaming service opens up to third parties

IT'S FAIR TO SAY Google's Stadia hasn't been a roaring success. Game streaming is a sound idea, but Stadia has struggled to deliver the performance the top titles need. It's still alive, but the push into the consumer market looks half-hearted at best. At the Game Developers' Conference, Google renamed the white label version of Stadia to "Immersive Stream for Games". This is open to third parties who can use all that development to provide their own streaming games without any Google branding. The first to benefit was AT&T, which is offering *Batman: Arkham Knight* to its customers. Google has a habit of dropping projects if they don't work immediately. It killed its own Stadia game studio before that could produce an original game and the new free Stadia account, with a limited trial of selected games, is too little, too late. Google is probably right in its decision to supply a streaming games platform to others to sell, as its own effort appears to lack conviction. **–CL**

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Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

✓ **LONGER BATTERY LIFE**
Japan has developed a new material that reduces capacity loss from battery recharging.

✓ **WORLD'S BIGGEST BORE**
Quaise Energy group is digging the world's deepest holes (over 12 miles) to tap geothermal heat as a renewable energy source.

✓ **WINDOWS DIRECTSTORAGE**
DirectStorage, a form of SSD acceleration, is finally here for Windows, though games will need support added to use it.

TRAGEDIES

✗ **APPLE OVERPRICING**
Apple's 1.8m Thunderbolt 4 cable costs $129, yet branded rivals are half the price and a generic version sells for $30.

✗ **HOLOLENS DISAPPOINTS**
Troops questioned the reliability and performance of Microsoft's mixed reality US Army headsets.

✗ **TESLA CANS CRITIC**
An engineer on Tesla's self-driving project was fired for posting a YouTube video showing one failing.

GPU PRICES FALLING FASTER

We aren't back to normal, but things are finally getting better

THE PANDEMIC made a complete mess of chip supplies and graphics card prices went through the roof, though now the end of this situation is in sight. Before we get too excited, we are still paying over the odds, but that's improving rapidly. There are many factors at play, including the volatile cryptocurrency market, which has affected prices under restricted supplies.

February saw a decent reduction in graphics card prices, and the latest figures put March's drop at about 12 percent. We've even heard of basic cards selling at near the recommended retail price, but generally, the premium ranges from 20 to 60 percent depending on the card.

A survey by online retailer Newegg put a GeForce RTX 3070 at a premium of 70 percent, while an RTX 3080 Ti was a more modest 19 percent. Cards released during the shortage often have a higher MSRP, so the premium looks less dramatic. Older cards launched with realistic and competitive MSRPs now look worse value than they are. High-end cards are still at crazy prices, just not as bad as they were.

Availability has also improved. Most cards are available, in some configuration or other, so the scalpers on eBay are finally starting to run out of willing customers. Since eBay takes a cut of the price, they can't survive without a decent premium. Is it time to buy yet? Probably not. Next month, the card you want will inevitably be cheaper. It might be worth waiting for the next generation of GPUs coming from Nvidia and AMD due before the fall, and we will soon have Intel's Arc Alchemy too. Looks like we are over the hump, and going downhill rapidly. Phew! **–CL**

This lovely GeForce RTX 3070 still comes with a nasty 70 per cent premium though.

SIX HUNDRED WATT GRAPHICS

New ATX standard clears the way for next-generation GPUs

TOP-FLIGHT GRAPHICS cards are notoriously power-hungry. The next generation of Nvidia RTX 4000 cards will continue this trend, and rumor has it that the AD102 GPU will debut with 450W and 600W versions, but talk of an 850W version is wild (think of the cooling that would need). AMD's next generation of cards, due later this year, is based on RDNA 3 silicon. Power requirements are expected to be less dramatic, but at 450-480W, not exactly parsimonious either.

To feed these cards, Intel has its new ATX 3.0 power supply specification, which was finalized in February. It's the first big change to the ATX standard since version 2.3 in 2007, which removed the 20A limit on the 12V rails. Expect it to be adopted quickly, cards have already outgrown the previous standard that offered a maximum of 300W to a PCIe card (75W via the slot, 75W with a 6-pin, and 150W via an 8-pin connector). Top cards have already broken the limit by using connectors or adapters.

ATX 3.0 aims to fix this with a new 16-pin 12VHPWR (12V high power) connector for PCIe 5.0 cards. It has 12 power pins, and four ancillary pins for signaling, these enable the graphics card and PSU to configure the power requirements. It can deliver 150, 300, 450, or 600W of power, assuming the PSU can reach such levels. The connector is required on all PSUs of over 450W, and the specs also require that the connector is labeled with the maximum power rating.

Any graphics cards unable to employ the signaling pins will be limited to 150W by default—from now, the PSU will set the power limit. If you're planning to upgrade to a next-gen graphics card, you may have to budget for an ATX 3.0 PSU too. **–CL**

Microsoft trying adverts in Windows, again

A NEW FEATURE HAS POPPED UP in a Dev Channel Windows build that has proved most unwelcome—advertisements. These pop up in File Explorer, promoting just Microsoft Editor so far. The online response was rapid and vociferous, as you might expect. Microsoft said that the feature was "not intended to be published externally", and has turned the ads off. The last time Microsoft tried to place ads in Windows, inserting them into a 2018 beta build of Windows Mail, it backtracked then, calling it an "experimental feature that was never intended to be tested broadly".

Though Microsoft experiments with new features in its development builds, its response isn't particularly comforting, as it's clearly still developing systems to include adverts in Windows. The company makes little profit from Windows sales, licenses for new machines cost little and the upgrade from Win10 is free, so it looks increasingly likely that Windows will not remain ad-free forever. With an estimated 1.4 billion Windows 10 and 11 PCs in the world, such potentially rich pickings are hard to ignore. Apple and Google currently spam you with offers, and many have become inured to their presence. If adverts do go live, there will be howls of protest, which might explain why the company is tip-toeing towards that day. **–CL**

Tabs in Explorer

A recent preview build of Windows included a neat new feature: tabs in File Explorer. The Mac has had these for years, but in Windows, you have to resort to opening multiple copies of File Explorer. The feature is currently hidden, and it's not clear how it will function yet. It's still early days and too buggy for a preview build.

The latest build also includes a new browser-based video editor called Clipchamp. The demand for basic editing is high, thanks to social media, and the discontinued Windows Movie Maker is sorely missed. The basic version will be free, but you'll have to subscribe for high definition. Win11 has struggled to be loved, something Microsoft has been addressing with each update. Explorer tabs will be a useful improvement. **–CL**

GeForce RTX 3090 Ti, finally

A while ago, Nvidia announced a new 'halo' card, the GeForce RTX 3090 Ti. This was a beast, with over 40 TFLOP of shading power, and 78 TFLOP for ray tracing. It also has a tasty 24GB of GDDR6 running at 21Gbps. It should have finally landed by the time you read this.

We've no idea why Nvidia delayed the launch, but early shots of the card show it sporting the new PCIe 5.0 power connector. This, and the specs, point to a power consumption of around 450W. Now the bad news. As Nvidia's top-flight card, it commands a premium, with online retailers asking up to $3-4,000. We expect that to fall, but the first ones to hit the market are going to get scalped. What the MSRP will be remains to be seen, and Nvidia may not even bother setting one for now. **–CL**

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Jarred Walton

TECH TALK

Nvidia Unveils Hopper H100 Datacenter GPU

WE'VE KNOWN NVIDIA has been working on next-generation GPUs for some time, but it officially unveiled its Hopper architecture and the H100 datacenter GPU at GTC 2022. Hopper H100 will replace the Ampere A100, which replaced the Volta V100. Designed for supercomputers, with a focus on AI capabilities, H100 provides numerous updates to the current A100.

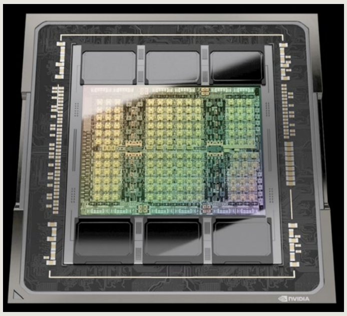
Built with 80 billion transistors on a custom TSMC 4N process (4nm Nvidia, not to be confused with the generic N4 that TSMC also offers), Hopper ups the ante in many ways. It supports a PCIe 5.0 interface, the first GPU to do so, as well as 4th generation NVLink, which can deliver up to 900GB/s of bandwidth, while PCIe 5.0 tops out at 128GB/s, 1.5x and double the bandwidth of the A100, respectively. H100 will have 80GB of HBM3 memory with 3TB/s of bandwidth, x1.5 faster than the A100's HBM2E.

The H100 can also deliver up to 2,000 TFLOPS of FP16 and 1,000 TFLOPS of TF32 compute—triple the performance of the A100. FP64 Hopper also adds improved FP8 support with up to 4,000 TFLOPS of compute, six times faster than the A100. For general purpose FP64 instructions, Hopper can do up to 60 TFLOPS—that's three times faster.

New to Hopper are DPX instructions, designed to accelerate dynamic programming and help with a range of algorithms, including route optimization and genomics. Nvidia claims performance is seven times faster than its previous generation GPUs, and up to 40x faster than CPU-based algorithms.

But this performance comes with a cost. Nvidia hasn't given details of price, but the TDP for the SXM variant that uses NVLink instead of PCIe sits at 700W, compared with 400W for the A100 SXM modules. That's a net improvement in efficiency, but also evidence of the slowing down of Moore's Law. A lot of that power goes to the interlinks with other GPUs, which are vital for increasing the scaling potential for supercomputers and their building blocks.

> There's speculation that top consumer GPUs could double the performance of the RTX 3090.



Nvidia's GH100 chip promises boosts in performance that will help shape our AI-driven future.

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As with A100, Hopper will be available as a new DGX H100 rack-mounted server. Each DGX H100 system contains eight H100 GPUs, delivering up to 32 PFLOPS of AI compute and 0.5 PFLOPS of FP64, with 640GB of HBM3 memory. Nvidia then scales out to a DGX SuperPod with 32 DGX H100 systems, linked by an updated NVLink Switch system and Quantum-2 InfiniBand networking. A single H100 SuperPod has 256 H100 GPUs, 20TB of HBM3 memory, and up to one ExaFLOPS of AI compute potential.

Nvidia has announced its new Eos supercomputer that follows in the footsteps of Selene. It's built from 18 SuperPods, with 576 DGX H100 systems and 360 NVLink Switches, with 275 PFLOPS of FP64 compute. More importantly in Nvidia's AI-focused future, it will deliver 18 EFLOPS of FP8 AI compute, or nine EFLOPS of FP16.

It's not just Hopper, Nvidia also has its Grace CPU that will provide up to 72 CPU cores, paired with LPDDR5X ECC memory. Nvidia will offer Grace Hopper "Superchips" that combine a Grace CPU with a Hopper GPU on a single module, with a 900GB/s coherent interface between the two. There's also a Grace CPU "Superchip" with two CPUs on a module, 144 CPU cores, and 1TB/s of memory bandwidth. While Hopper will arrive later this year, Grace isn't due until Q3 2023.

While Nvidia likely won't use HBM3 or TSMC 4N for its upcoming Ada GPUs, and may not triple the performance of Ampere, there's speculation that the top consumer GPUs could double the performance of the RTX 3090. Based on Hopper, such rumors may not be that far-fetched.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

THE LIST

THE TOP MICROPHONES

6

BLUE YETI NANO For great audio without all the bells and whistles, Blue has you covered with the Yeti Nano. The brand of choice for professional podcasters, Blue's latest mic has a smaller footprint than the original Yeti, fewer recording options (cardioid and omnidirectional), and a plastic finish. However, it has enough features for the majority of podcasters, streamers, and musicians. **$80** bluemic.com

5

NZXT CAPSULE MIC This microphone has a quick-release stand, making it ideal for recording on-the-go. It's stylish, well made, and easy to get up and running. There's a USB-C connection on the bottom of the mic, plus an easily-accessible mute button and a light ring that lets you see when you're broadcasting. However, it only records cardioid (front of mic), so it's not ideal for interviews. **$130** nzxt.com

4

ELGATO WAVE:3 Elgato is no stranger to premium gaming accessories, and the Wave:3 is beautifully made but more expensive than its rivals. The flat design saves space, it connects via USB-C cable, and the lighting on the front of the mic lets you see audio levels and whether you're muted. However, it only does Cardioid recording, there's no RGB lighting, and you have to buy the shock mount separately. **$160** elgato.com

3

AVERMEDIA LIVE STREAMER MIC 330 This microphone is ideal for live streamers and podcasters. Its XLR connection means you can pair it with a mixing deck, such as AVerMedia's Live Streamer AX310. This Cardioid mic does an excellent job of picking up what's in front of it, though it doesn't boast fancy lighting or omnidirectional recording. **$100** avermedia.com

2

MSI IMMERSE GV60 MSI's gaming peripherals tend to be unassuming, well made, and priced competitively. The GV60 carries on that tradition with all the features you'd want at this price. The front houses the controls, including four different audio pickup styles, mic and audio balancing, and a mute button. It also uses USB-C connectivity, while the package includes a pop filter for clearer sound. **$130** msi.com/Gaming-Gear

1

HYPERX QUADCAST HyperX's mic boasts a sturdy construction and is easy to mount, either in the included desk stand or on a mic arm. There are four audio pickup modes including omnidirectional, and it looks great thanks to sleek red lighting that indicates when you're recording. A touch-sensitive mute button allows quick and easy privacy. **$150** hyperxgaming.com

© BLUEMIC, NZXT, ELGATO, AVERMEDIA, MSI, HYPERX

Jeremy Laird

TRADE CHAT

Affordable graphics cards here at last?

IGNORE THE CATASTROPHISTS, graphics card pricing is finally returning to normal, or rather a new "normal" thanks to MSRPs that are higher than ever before. But however you slice it, graphics cards are now cheaper than they were a few months ago.

Nvidia's RTX 3080 is finally affordable. Well, kinda...

© NVIDIA

Actually, GPUs will probably be cheaper still by the time you read these words. Reports of graphics card prices falling off a cliff are coming in from across the globe. In Australia, the Asus GeForce RTX 3080 TUF Gaming OC plummeted from AU$2,299 to AU$1,499 overnight, an incredible drop of 35 percent from one day to the next.

That's still around 50 percent above the AU$999 MSRP for a reference Nvidia GeForce RTX 3080, but it's a huge step in the right direction. Similarly, in Europe, RTX 3090s have dipped below €2,000 for the first time since March 2021. Back in the US, RTX 3080 pricing now starts a little over $1,000.

Likewise, that's well above the 3080's rather notional $699 MSRP, which now seems like an incredible deal. But around April and May last year when GPU values peaked, the average price of an RTX 3080 was around $2,200, if you could find any availability. Instant gratification on eBay at the time? You were looking at a painful $2,500.

The same downward trend applies to AMD GPUs, even if many of them remain poor value. The vanilla Radeon RX 6800, for instance, is down to under $1,000 having peaked at $1,500. Then again, the 6700 XT can now be had for about $600, which isn't much more than that GPU's $480 MSRP. As for RX 6900 XTs at $1,299, they don't look all that bad next to the $999 MSRP, either.

There's every reason to expect prices to keep falling. AMD and Nvidia are producing more GPUs than ever. Right now, availability of all current AMD and Nvidia GPUs is good, which is a key factor in driving prices down. Meanwhile, the most GPU-relevant cryptocoin, Ethereum, remains miles below its $3,600 peak back in November. In other words, mining crypto isn't as profitable as it was, so crypto-based demand for GPUs has nosedived fairly dramatically.

> All of this begs the question of whether you should buy now or hold out a little longer?

What's more, Intel is just about to flood the market with four million gaming graphics cards. It's yet to be seen how good Intel Arc graphics will be. But a very plausible rumor doing the rounds suggests Intel is willing to sell them off below cost in order to acquire some early market share. If that's true, this summer could be a bit of a bloodbath for GPU pricing, especially in the low to mid-range. It's unlikely that Intel Arc will be fast enough to compete with cards like the RTX 3080, RX 6800, and above, though.

The kicker later this year will be new GPU families from AMD and Nvidia. RDNA 3 and Lovelace, respectively, are expected to deliver a major step-change in performance. It's likely, therefore, these new chips will push prices of existing GPUs even lower. Some real bargains could be on the cards for the latter half of 2022.

Without wanting to sound tone-deaf in the face of a major humanitarian crisis, the current geopolitical situation is a worry for the semiconductor industry. Just as the chip shortage is easing, there's a risk that supplies of neon gas, which is critical for the silicon lithography process used to manufacture computer chips—a large proportion of which comes from Ukraine—could dry up.

The chip industry has reportedly stockpiled for this contingency, so there's limited immediate risk to production. But even if supplies of neon do get dicey, the point remains. GPU pricing was always going to normalize. There was no way $1,000 was going to become the new normal for a mid-range gaming graphics card. Not when a games console costs half that.

All of which begs the question of whether you should buy now or hold out a little longer? That's a tough call. On balance, it's likely that prices will continue to fall. And those upcoming GPUs could be stellar. But if you've already been waiting 18 months, I wouldn't blame you for pulling the trigger sooner rather than later.

Six raw 4K panels for breakfast, laced with extract of x86... Jeremy Laird eats and breathes PC technology.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

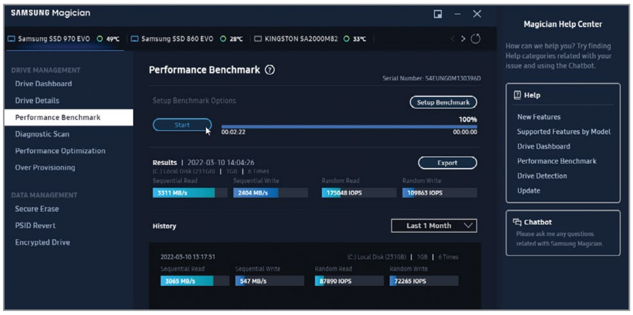
> All-in-one laptop
> SSD Win11 bug
> Transfer Windows 10

PC TV?

I have a TV hanging on the wall of my kitchen. It's nice, but it's not a computer. How can I get a microcomputer glued to its back panel with Bluetooth connections to a keyboard and mouse? I was thinking about stripping down an old laptop, attaching its working parts to the back of the TV, and using a wireless mouse and keyboard with it. It would need Wi-Fi, as well as Windows. **—Gary Dent**

THE DOCTOR RESPONDS: The problem with stripping down a laptop is that its parts have been custom designed for that specific model and manufacturer, and the case designed around it.

While some laptops are easier to disassemble than others—Google your manufacturer and model with the words 'service manual' to find a detailed manual—there's still the question of what to do with the bespoke components inside. You won't, for example, be able to rehouse them in a standard or mini form factor case; in fact, you'd almost certainly need to build your own custom case designed for the components you've plundered.


SAMSUNG Magician
Samsung SSD 970 EVO 49℃
Samsung SSD 860 EVO 28℃
KINGSTON SA2000M82 33℃
DRIVE MANAGEMENT
Drive Dashboard
Drive Details
Performance Benchmark
Diagnostic Scan
Performance Optimization
Over Provisioning
DATA MANAGEMENT
Secure Erase
PSID Revert
Encrypted Drive
Performance Benchmark
Setup Benchmark Options
Setup Benchmark
Start
Export
History
Last 1 Month
Magician Help Center
Help
New Features
Supported Features by Model
Drive Dashboard
Performance Benchmark
Drive Detection
Update
Chatbot

Serial Number: S4EUNG0M130396D

100%
00:02:22 00:00:00

Results | 2022-03-10 14:04:26
(C:) Local Disk (231GB) | 1GB | 6 Times
Sequential Read 3311 MB/s
Sequential Write 2404 MB/s
Random Read 175048 IOPS
Random Write 109863 IOPS

2022-03-10 13:17:51
(C:) Local Disk (231GB) | 1GB | 6 Times
Sequential Read 3065 MB/s
Sequential Write 547 MB/s
Random Read 87890 IOPS
Random Write 72265 IOPS

How can we help you? Try finding Help categories related with your issue and using the Chatbot.

Please ask me any questions related with Samsung Magician

Native SSD drivers offer better performance.

© SAMSUNG

Long story short, the costs, expertise, and time involved in such a project—with no guarantee of success at the end of it—are prohibitive in the Doc's eyes. Depending on the size of the TV and the strength of its mount to the wall, you could consider simply fixing the laptop behind it with the lid permanently closed.

If you go down this route, you'll need to disable any power controls such as sleep or shutdown associated with closing the lid, plus configure it to ignore the built-in display in favor of the TV. Then pair an external wireless keyboard and mouse to it via Bluetooth and hey presto: a clunky, but working PC behind the TV.

Perhaps a better approach is to consider investing in a mini-PC—one designed to be affixed to the back of a display using its VESA mounts. These are surprisingly affordable, if low-powered. The Intel NUC 10 series is one to look out for—these barebones systems require you to add your own RAM, storage, and copy of Windows, and come in a staggering number of configurations to suit every pocket and purpose.

Better still, NUC 10s use laptop-friendly SO-DIMMs, so there's a possibility you could marry up a system to your old laptop to enable you to salvage the RAM and storage from your old system. For example, if your laptop supports the older DDR3L RAM, then an Intel NUC BOXD3401 system is a good budget choice, sporting a 4th generation Core i3 processor for just $289, but it's a bit bulky for sitting behind a wall-mounted TV and there's no built-in Wi-Fi or Bluetooth. Search newegg.com for 'Intel NUC BOXD34010WYKH'.

The newer Intel NUC 10 BXNUC10i3FNKN1 costs just $329 (also newegg.com), supports SO-DIMM DDR4 2666 RAM, and has both Bluetooth and Wi-Fi built-in. It's also powered by a newer 10th generation Core i3 processor, and more powerful i5 and i7 models are available for a premium. This also has a much slimmer case, making it more suitable for placing behind a wall-mounted TV.

Win11 SSD slowdown

First of all, thank you for your awesome magazine and talented authors who write informative articles. I was reading about SSD slowdowns related to Win11 and Samsung SSDs in your latest issue.

I just conducted a performance benchmark of my Samsung 970 EVO Plus and have noticed that it is slightly slower than before I updated to Win11. I'm thinking that this might be more of a firmware issue rather than an issue with Win11. What do you think? **—Scott Cortese**

↘ submit your questions to: doctor@maximumpc.com

THE DOCTOR RESPONDS: It's almost certainly an issue with Windows rather than Samsung, Scott. First, the performance issue affects a wider range of SSD and NVME drives than just Samsung. Second, it's only apparent on system drives, so if you're using SSD and NVME drives for pure data storage, performance remains strong.

And crucially, Microsoft has already issued one update that acknowledges the problem and has—successfully for some—attempted to fix it, namely KB5007262. That update claimed to address an issue that affected the performance of any hard disk in Windows 11 through performing unnecessary actions when the NTFS USN journal was enabled, which is always the case on the C drive.

That said, it pays to check for firmware updates in case these can help mitigate the issue. A recent firmware update for the 980 has reportedly delivered much better random read/write speeds, but no such firmware update has been issued for the Samsung 970 EVO line. That said, if you've not yet done so, installing Samsung's NVME drivers in place of the standard Microsoft ones should yield performance benefits too—the Doc witnessed small, but noticeable improvements in both random read and write times with his 970 drive after installing Samsung's drivers.

External optical enclosure

Would you have suggestions or recommendations for those of us who want to do a new build but aren't ready to go without our optical drives?

—James

THE DOCTOR RESPONDS: Optical drive enclosures are becoming almost as rare as optical drives, particularly when it comes to full-height 5.25-inch optical drives. In fact, your options are limited to just one that we could find: the OWC Mercury Pro 5.25-inch Optical Drive External Enclosure, which will currently set you back $65 when purchased direct (https://eshop.macsales.com/item/OWC/MR3UKIT/). For just $25 more you can purchase an external Blu-ray burner—$90 buys you a MthsTec USB 3.0 and Type-C model from Amazon (www.amazon.com/dp/B07SZKNRF2).

It's a lot less expensive if you're looking to repurpose a laptop optical drive—StarTech offers a USB 3.0 model that supports the slimline SATA models found in many laptops for just $27 (www.startech.com/en-us/hdd/slsoddu33b).

KeePass follow-up

I read with interest your response in the February 2022 issue of the mag to an inquiry about KeePass. I was a little surprised that you stated that "KeePass development has stalled of late." I don't believe this to be true. Their website at www.keepass.info shows regular updates, the latest being January 9, 2022 (as I write). That version is v2.50.

I have been using KeePass for many, many years ever since reading of its recommendation in *MaximumPC*, and it has served me well. I was not aware of KeePassXC mentioned in your reply, but it appears to be a fork of a fork of KeePass. All good, but perhaps you could tell us about the differences between the original KeePass and the two forks along with their pros and cons? I have noticed that KeePass does not appear in your recent reviews of password managers for some reason.

—Dennis Younker

THE DOCTOR RESPONDS: Apologies, Dennis, the old Doc didn't make it clear he was primarily referring to the KeePass 1.x fork that Steve was using. You're right, of course, that KeePass 2.x continues to be updated two to three times a year. The major reasons for the Doc's recommendation to Steve that he switch to KeePassXC are that it sports a more modern interface, runs natively on Linux. macOS and Windows, and offers better integration with web browsers through plugins, all of which addressed Steve's concerns.

The reason why KeePass hasn't featured in recent password manager roundups and reviews is related to these shortcomings—it's a capable password manager, but lacks the cross-platform support found in other tools that enable you to carry your passwords securely on your phone or sync them to other computers in your household, never mind simplify the logging into websites or filling in online forms.

While there are third-party solutions based on KeePass to extend its support to other platforms and devices, it's not as elegant or unified a solution in the Doc's eyes as the likes of Buttercup (https://buttercup.pw/) or Bitwarden (https://bitwarden.com), which can be run on your own server for maximum security.

Cheap Windows 10

I am rebuilding an old computer from information in your 'The Build' section—replacing a 12-year-old mobo and CPU and moving from 32-bit OS to 64-bit. That section shows the price for the Window OS as $32, but I cannot find where to purchase it at that price. I recall seeing this explained in a previous issue, but didn't keep my old copies. Could you refresh my memory of where to purchase the Windows 10 Home 64-bit OEM OS for $32?

—Charles Zimmerman

THE DOCTOR RESPONDS: Google 'Windows 10 OEM' and you'll see lots of online stores offering OEM licenses at deep discounts, many under $50, and you may even see one or two below $30. In many cases, these licenses should work fine, but you're taking a risk.

Note that you don't need to purchase a new license when switching from 32-bit to 64-bit, only when moving between Home and Pro versions of Windows 10. This means if you'd successfully installed Windows 10 on your old hardware, you'll potentially be able to transfer the license from it to your newly rebuilt PC.

If your old PC is running, go to 'Settings → Update & Security → Activation' to verify its status—make sure it's both digital and linked to your Microsoft Account (click 'Add an account' if this isn't the case). Alternatively, log on to your Microsoft Account at https://account.microsoft.com and check the Devices list. If your old PC is here, you'll be able to transfer the license.

Once you've confirmed the existence of an existing digital license for transfer, perform your rebuild and install Windows 10 using 64-bit install media, which you can create using the tool at www.microsoft.com/software-download/windows10 in conjunction with a USB flash drive or blank DVD. You should be given the option of creating 64-bit install media during the setup process.

After installing Windows 10 on your new build—skip the prompt for a product key when prompted—make sure you're signed into your Microsoft account during installation and then head over to 'Settings → Update & Security → Activation' where you should click Troubleshoot to follow the steps provided in the Activation troubleshooter.

Be sure to select your 'old' PC as 'This is the device I'm using right now' to transfer the license across. After clicking 'Activate' the process should be done. If you run into any errors, check https://support.microsoft.com/en-us/help/10738 for a guide to what the error message means and what to do next.

MINI MEDIA MASTERPIECE

A shelf-sized home-theater and couch gaming machine? You can count us in

GENERALLY SPEAKING, desktop PCs are our forte, but we don't want to shy away from the obscurities out there. Mini form factor machines have always caught our eye, though their inherent restrictions and performance limitations can often dampen our initial interest. However, Intel's latest NUC 12 Extreme 'Dragon Canyon' kits have well and truly sparked that fire in our bellies and we are looking forward to getting right into this rig.

We'll be tweaking this system to create a small, minimalistic home media and couch gaming system. To spice things up, we'll be pairing it with XGIMI's Halo Plus projector. This little companion will sit alongside the NUC 12 on a shelf to provide a discreet setup. There's something exciting about playing games on the big screen and you can't beat it for kicking back and binge-watching a Netflix series.

One stand-out positive to having a smaller setup is less mess. Therefore we are aiming to create a more seamless and less cluttered experience without the compromise of less power in this rig. The Intel NUC 12 Extreme is the same design as the last Intel NUC 11, but this is a good thing. Measuring just 7.4-inches by 14-inches, it's far smaller than a competitively-specced Micro ATX machine but still has the ability to support a full-sized GPU.

Coming pre-installed with the i9-12900 CPU, it's no surprise that you can spec this tiny machine up to get some serious top-end performance. That's a plus for us as this will hopefully make the perfect couch gaming unit. Pair this with a wireless keyboard and trackpad, wireless controller, a decent set of speakers or headphones and you've got yourself a mean media center that doubles as a casual gaming rig. That's the idea anyway, so let's see how it fares. –SAM LEWIS

GPU

GIGABYTE GEFORCE RTX 3050 GAMING OC 8GB

RRP: $379.99 / STREET PRICE: $486

One stand-out feature of the Dragon Canyon is its compatibility with full-sized desktop GPUs. Of course, when given this information, our first thought was to throw in a 3090 and make a powerhouse gaming monster. Sure, that would tick a lot of boxes, but it would also send this somewhat pricey PC kit up into the stratosphere.

For a home theater that doubles as a casual gaming rig, an RTX 3050 is a more than capable card. This entry-point 30 series GPU from Gigabyte is the Gaming OC variant. This brings in higher clock speeds and 8GB of GDDR6. This will easily allow for 1080p gaming through a projector and, alongside the NUC's i9-12900 CPU, it should also offer a comfortable level of future-proofing.

As one of the easiest 30 series cards to obtain and priced below $500, this is a strong card for your money.

GIGABYTE.COM

MEMORY

16GB (2x 8GB) HYPERX IMPACT CL20 DDR4-3200 SODIMM

RRP: $100 / STREET PRICE: $100

Although the Intel NUC 12 Extreme can house a full-sized GPU, it will be a struggle to fit DDR4 DIMM sticks. To allow room for the GPU, we have opted for some solid HyperX Impact SODIMM sticks in our build, specifically a 16GB kit. This isn't a bad compromise—the memory speed is also capped at 3200MHz, so while RAM isn't its strongest point, that speed is good enough for our build.

We don't often turn to this format of SODIMM RAM but with a smaller case, it's a necessary move. Thankfully, it still provides speedy performance and more than enough capacity.

While they look sharper than standard DIMM sticks, you won't be able to see them, as they will be hidden right in the depths of the NUC's compact case.

CORSAIR.COM

STORAGE

SAMSUNG 980 1TB M.2 SSD

RRP: $140 / STREET PRICE: $99

We need a decent amount of storage for a media center and speedy SSDs for the gaming element, so we decided to pick two great drives—one of which is Samsung's 980 1TB SSD. This isn't PCIe 4.0, although it still is a nippy and affordable drive. On sale at $100, this is a great pick-up.

WWW.SAMSUNG.COM

WD_BLACK SN850 1TB NVME SSD

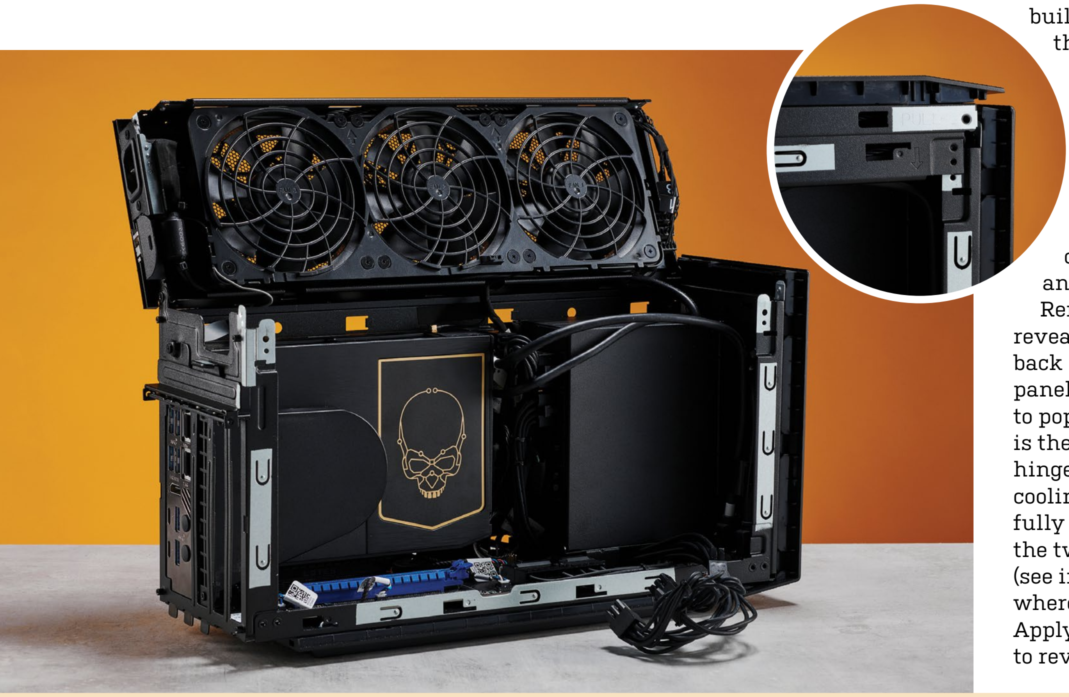
RRP: $190 / STREET PRICE: $150

Our more powerful SSD is Western Digital's Black SN850 drive, which has PCIe 4.0 support, and a capacity of 1TB and is currently on sale at around $150. We will use the WD SSD for games, as it has the speedier PCIe 4.0 format. The Samsung 980 SSD will be used for films and entertainment purposes, making a sweet storage duo.

WWW.WESTERNDIGITAL.COM

DIGGING INTO THE NUC

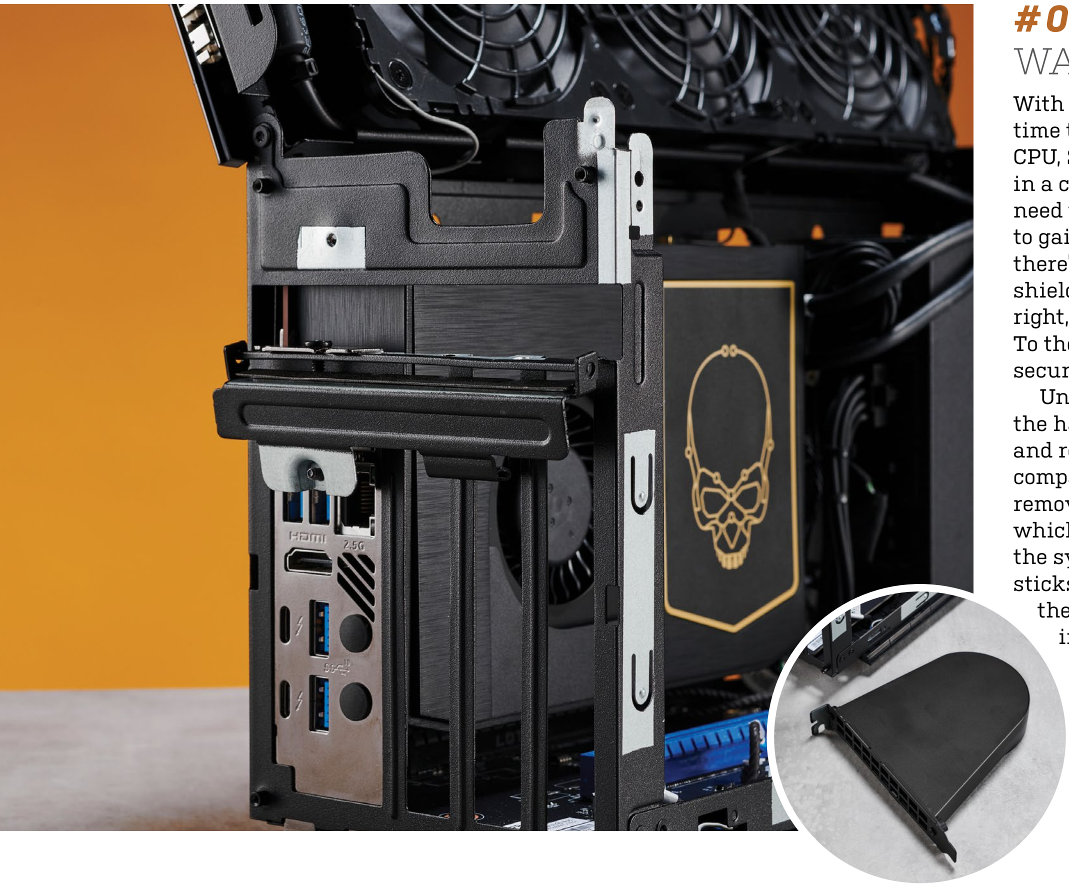
HOME ENTERTAINMENT DELIGHT OR A NIGGLY NIGHTMARE?



#01 UNLOCKING THE PUZZLE

You'd think that undoing a few screws and opening up a case would be one of the easiest parts of building a machine. However, on this occasion, the Intel NUC 12 Extreme left us scratching our heads as we tried to pop open the side panels and the front of the case. A quick Google search left us embarrassed—we'll put the fact that we didn't notice the four Philips screws on the back of the case down to an early morning start.

Removing the back of the case reveals the bare I/O ports. With this back panel off, we can slide the side panels toward the back of the case to pop them off. The last part to open is the top compartment. This is a hinged door that houses the system's cooling fans and doesn't need to be fully removed. To open this up, locate the two 'PULL' indicators on the hinge (see inset), as these point towards where you can lift the hinge up. Apply slight pressure and pop this up to reveal the opened NUC 12 case.



#02 MAKING OUR WAY TO THE CORE

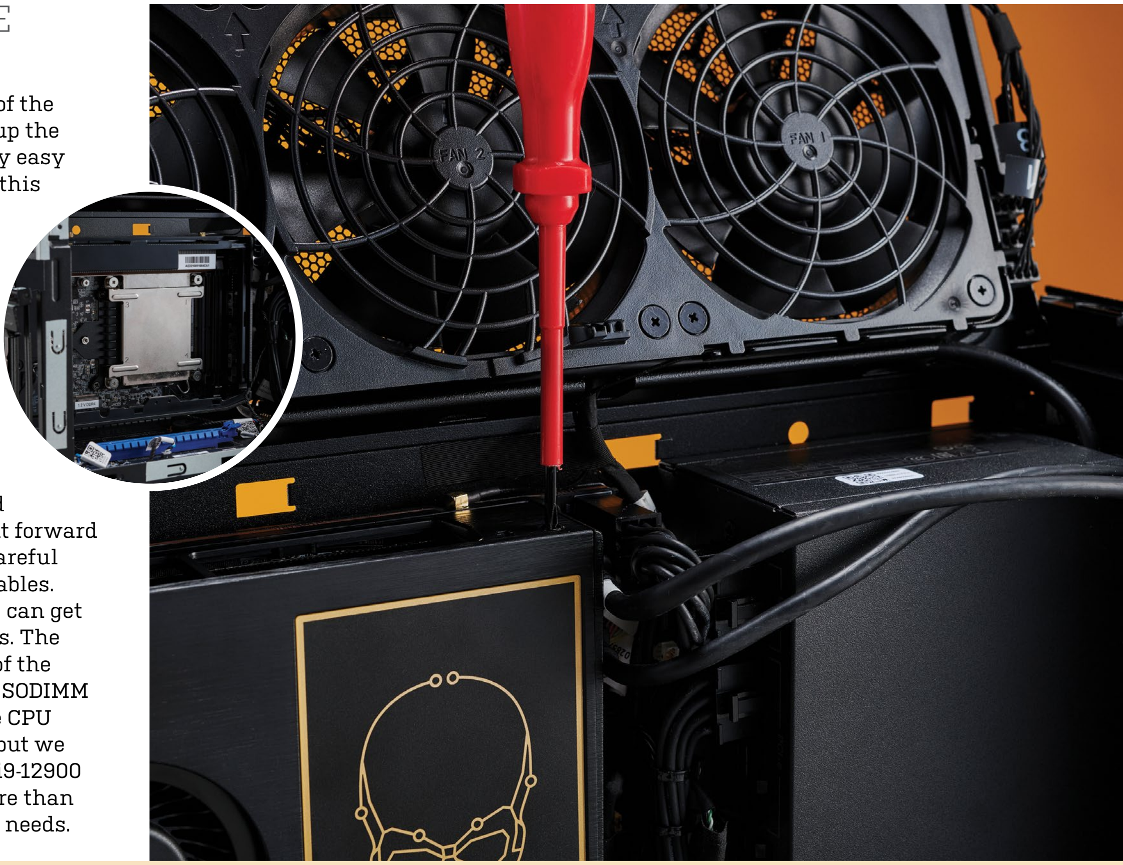
With the Intel NUC opened fully, it's time to get down to business. The CPU, SSD, and RAM slots are hidden in a compartment of the NUC and we need to release a few doors and parts to gain access. At the back of the case, there's a hinge that sits above the I/O shields with a little handle on the right, just below the power connector. To the left of this is a screw that secures the hinge in place.

Untighten this screw and use the handle to pull down the hinge and reveal the shield screws. One compartment that needs to be removed is the air chamber (pictured), which connects to the main hub of the system where our SSDs and RAM sticks will go alongside the CPU. Undo the screw that holds this chamber in place and remove this plastic compartment, putting it aside for later. While working on any build, a handy tip is to have a magnetic screw plate to keep your screws tidy—this saves wasting time hunting around for missing screws.

#03 INSIDE THE SECRET LAIR

Now the air chamber is out of the way, we have room to open up the compute unit. This is a fairly easy step but, like the top hinge, this panel doesn't fully come off and you need to be careful not to pull out the cables attached to it. Thankfully, the cable is long enough so that you can move this cover out of the way when completing the rest of the build.

It's secured with two screws at the top of the housing. Unscrew these and following the arrows, slide it forward gently to open it up, being careful not to pull too hard on the cables. With this out of the way, we can get to installing the components. The SSDs are housed to the left of the panel, so we can install the SODIMM RAM sticks to the right. The CPU is still underneath a cooler but we aren't replacing this as the i9-12900 is a monster chip that is more than powerful enough to suit our needs.

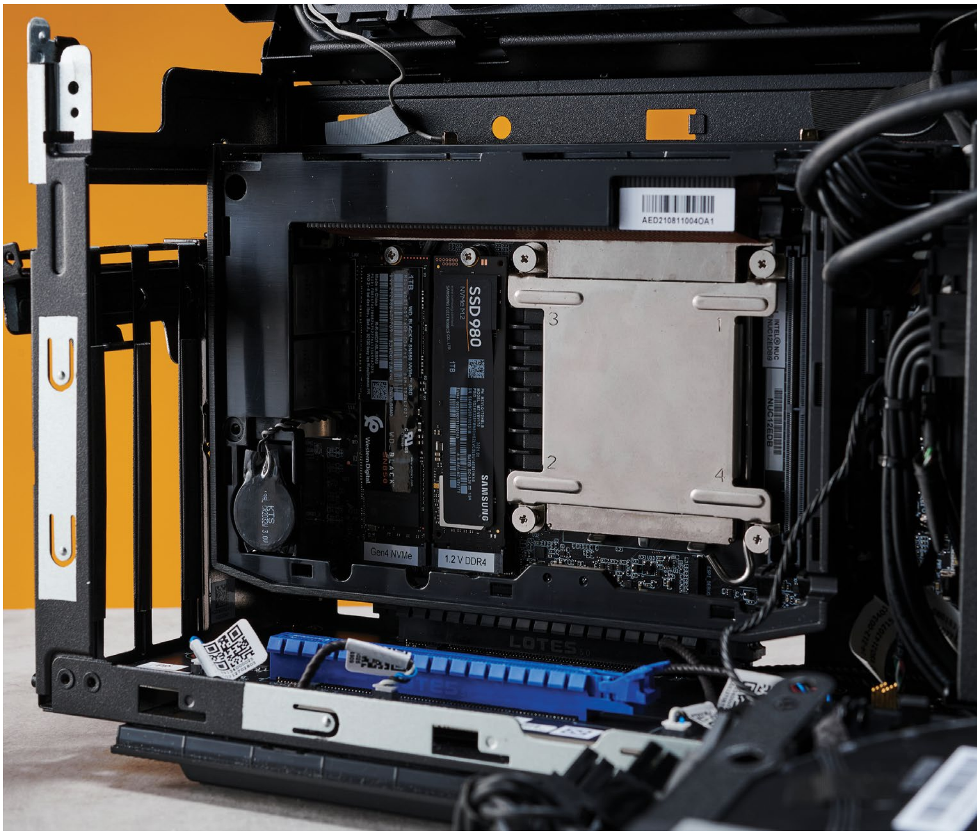


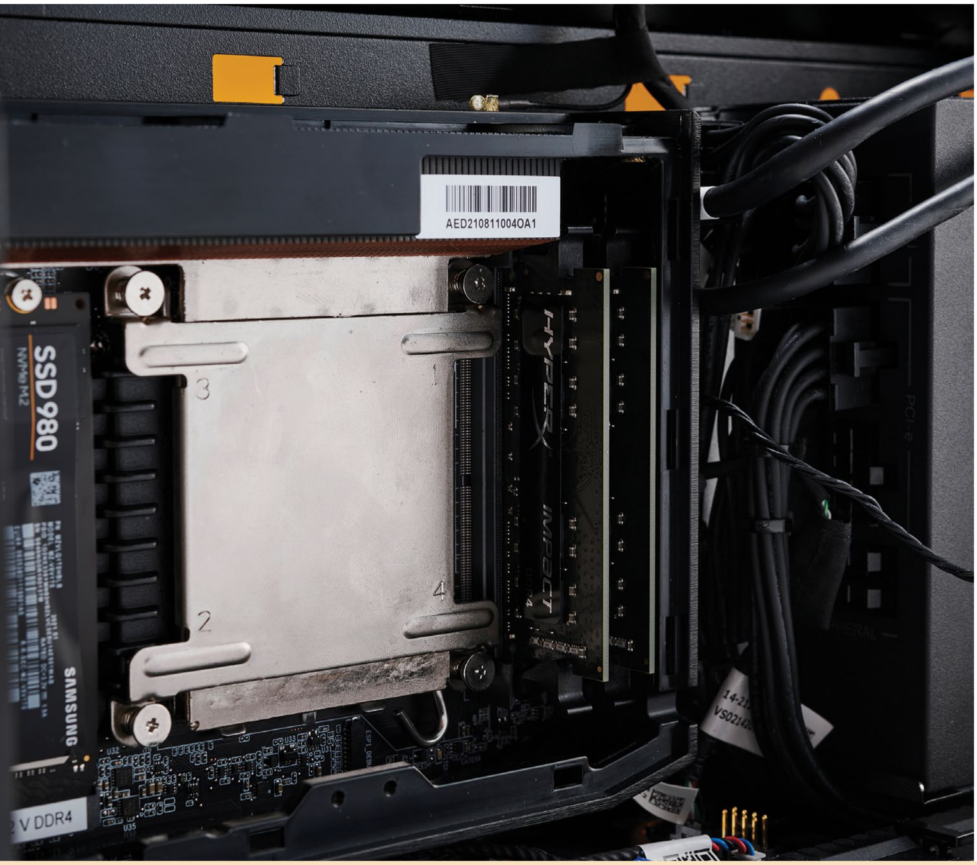
#04 ADDING THE STORAGE

Right, we'd best get some drives in this build. As we mentioned, the left side of the compute unit is where the SSD slots are located.

Unlike typical M.2 slots found on more standard motherboards, we will be vertically installing these, although the process is practically the same. The casing already has heat sinks installed so make sure your SSD doesn't have a heatsink shield. First, you need to remove the tiny top screw. Make sure to put this somewhere safe, such as the magnetic plate we mentioned earlier. These are a real nuisance to find again if you drop it into the case.

After you've removed the screws, insert the chip end of the SSD into the bottom of the slot at a 30° angle. This should slot in further and then you can push the drive down into place. Grab the screw again, align the hole on the SSD and tighten the SSD down onto the board. Repeat this process again to install the second SSD—if, like us, you chose to use two.



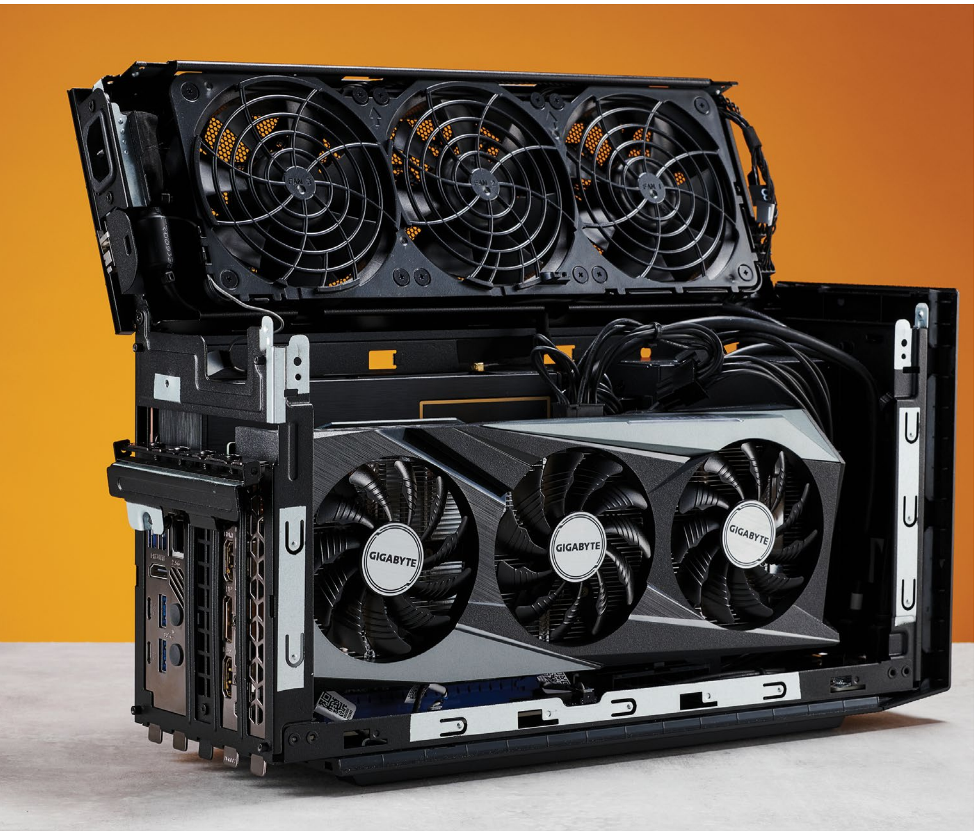


#05 MINI RAM TIME

Installing the RAM is a simple process in most builds, with only a few things that can go wrong. If you install a RAM stick in the wrong slot, it can cause booting issues, but there are only two slots to use and we have a 16GB kit of 2x 8GB sticks, hopefully, we won't mess this one up.

First, we need to press down on the clips above and under the slots to open them up. This can be quite fiddly due to the small nature of the NUC, so you can use a small screwdriver to open these clips if necessary. Then, just like on a typical DIMM slot, align the notch on the bottom of the SODIMM sticks to the slot on the board. Once aligned, give the stick an even push down onto the board and you should hear a satisfying click. This signifies that the RAM is firmly in place, but just make sure that the clips are secured down too.

Repeat this for the other stick and your RAM should be properly installed. Take your time with this as the Intel NUC is a small machine and that can make these installations a bit more cramped than usual.



#06 GPU INSTALL

We are nearing the end of this mini-build and what better way to finish than with the graphics card? It still seems crazy that you can slot a full-sized GPU inside this tiny case, but apparently you can, so it's time to give it a go. Although we initially thought this was going to be difficult to install due to the lack of room, it's a pleasant surprise and not frustrating in the slightest. Before we start with the GPU though, we need to add the compute unit's casing back on, then re-install the air chamber housing.

Once that's done, we need to make sure the PCIe slot clip is open, just like that found on the SODIMM slots for the RAM. Take the I/O end of the GPU and align it into the back of the case, making sure the connector on the graphics card aligns with the PCIe slot. Once aligned, press down evenly to click the card in place. Secure the graphics card by screwing the shield in place and then connect the PCIe cable from the Intel NUC's pre-installed PSU. After this, all we need to do is panel the machine back up and plug this beauty in to power.

PROJECTOR

XGIMI HALO+

RRP: $849

In keeping with the diminutive size of our Intel NUC 12 Extreme, this mini projector from XGIMI makes a great sidekick. Then, a wireless keyboard with a trackpad and games controller are all you need to get a kick-ass setup in your living room.

There are a few shortcomings with our projector setup, mainly that you need to have blackout blinds or curtains to help get the best picture, and also that the room looks empty when our system is off. TVs have been at the center of our living rooms for years and ditching one for a projector can take some getting used to.

Those issues aside, the immersive experience you get when you crank the screen up to as big as you can go and then hook it up to a monster PC is impressive—something you just don't get from typical displays. Sure, the picture quality won't match that of a 4K OLED panel, but the XGIMI Halo + is certainly not distracting and it truly feels like you are bringing the big screen into your home.

Oh, and did we mention that it's portable and features sound by Harman Kardon?

XGIMI
HOME SMART PROJECTOR
AUTO KEYSTONE
harman kardon
XGIMI

SEE REVIEW PG. 82

ENTERTAINMENT EXCELLENCE?

ALL YOU NEED FOR A CAPABLE HOME THEATER

AS MUCH as we all enjoy the journey, the end product is where we can start to get properly excited and dig deep into the build. Granted, this was a slightly different approach to our typical builds as we were taking a look at Intel's new NUC 12 Extreme kit, codenamed the 'Dragon Canyon'.

Usually, when working on smaller builds this means an abundance of head-scratching, tight spaces, and not a lot of clearance. Although the latter point is valid in this build, and we did have a bit of head-scratching when it came to opening up the case, the rest of the build went pretty smoothly.

The Intel NUC's interior space has been designed incredibly efficiently to house a range of high-performance components in such a small form factor, making it ideal for our intended outcome. It can be hidden behind your TV, in a cabinet, or on a shelf paired with a mini-projector, such as the XGIMI's Halo+ (see panel).

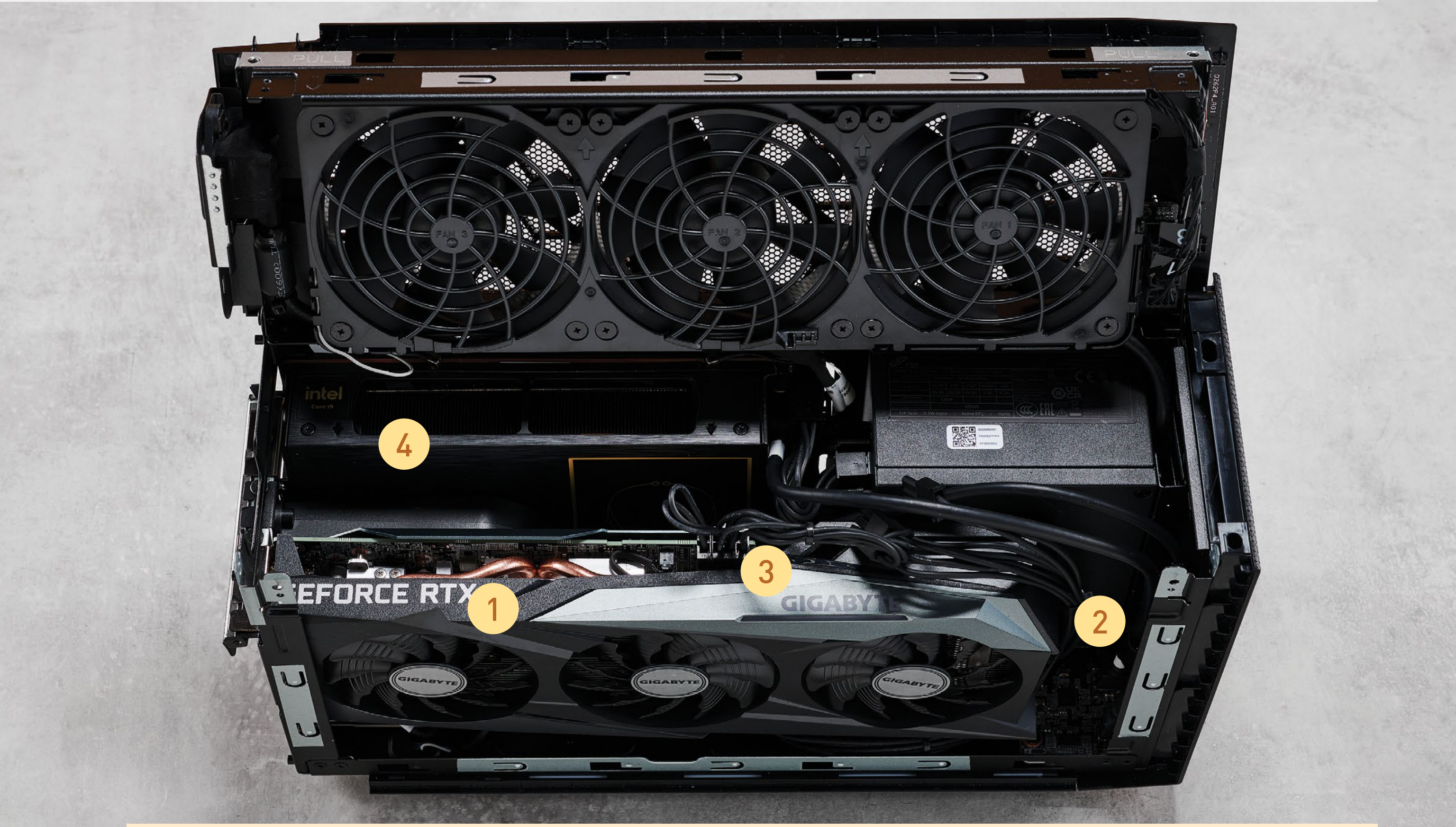
This system goes against the grain by being able to compete against other systems double, and in some cases, almost triple its size.

Visually it's not the most striking device and its LED skull logo on the front of the case may not be to everyone's taste, although this can be disabled in Intel's software. The case also features an underglow, favored by car enthusiasts of years gone by. If you're familiar with the *Fast and Furious* franchise, you may mistake this for a Toyota Supra at first glance. This LED light gives a nice even glow, however, we turned it off in our system as we wanted our room to be as dark as possible when using the projector.

So physical aspects ticked, how does this perform? On paper, it should certainly be more than good enough for a media center, while also doubling up as a casual gaming system through the projector. Of course, if you hook this up to a decent monitor with a high refresh rate, you'll be able to game at a more competitive level. As impressive as the XGIMI Halo+ is, we don't necessarily recommend going into a paid CSGO tournament on your sofa.

Anyway, it turns out that this machine performs just as well as we hoped. For its size, we were impressed with the PC's thermals and the lack of noise from the case. The i9-12900 worked in harmony with the RTX 3050 OC from Gigabyte and playing titles such as *GTA V*, *The Witcher 3*, *Forza Horizon 5*, and even the occasional game of *Cyberpunk 2077* was a great experience on the big screen.

The setup breezed through our benchmarking results, meaning it's not just a capable PC for everyday use, but also a solid gaming device. We were easily achieving over 60fps on 1080p with the settings cranked to the right. Although it's being played through a 60Hz display, it still felt smooth, and the overall aesthetic of



1 For our intended outcome, an RTX 3050 has more than enough punch to power our machine. But, if we were to use this strictly as a gaming rig, that would pop out and an RTX 3090 would find a home there instead.

2 Aside from the underglow RGB and the Skull on the front of the case, there is no RGB that pops inside of the case through the vents. Adding some internal lights could have spruced this machine up a bit.

3 A single-ended PCIe cable to the GPU would have kept things a little neater in the case, however, we had to try and tuck away the extra unnecessary ends from this cable.

4 Though our choice of two 1TB SSDs was more than adequate for our needs in this build, we could have added two 2TB SSDs instead. This would have future-proofed this device for a media center unit.

a projector provided a new way to experience these familiar titles.

For media consumption, it was a dream, as we paired the NUC 12 Extreme to a wireless mini keyboard with a trackpad, meaning that we didn't even have to get up and leave the couch. Of course, the endless amount of on-demand services available online means that you're likely to have a huge catalog at your fingertips. With 2TB of fast storage, it's also an ideal PC to store all your favorite films. Again, the home-theater aesthetic ticks all the right boxes, and what better way to experience this than with a powerful and discrete mini-PC?

It's also a portable system, as is the projector, so as long as you have power, you can take this on the road with you and have some entertainment ready wherever you are. On the flip side, if you fancy having a lazy day on the sofa doing nothing, this setup will also be your best companion. ⏻

BENCHMARKS

	ZERO-POINT	
CineBench R15 Multi (Index)	1,778	3,359 (89%)
CrystalDisk QD32 Sequential Read (MB/s)	3,557	6,929 (95%)
CrystalDisk QD32 Sequential Write (MB/s)	2,779	5,281 (90%)
3DMark: Fire Strike (Index)	14,995	15,214 (1%)
Rise of the Tomb Raider (fps)	113	119 (5%)
Total War: Warhammer II (fps)	72	81 (13%)
Tom Clancy's Ghost Recon: Wildlands (fps)	57	64 (12%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point is the $1300 build, with an Intel Core i5-12400, Nvidia GeForce RTX 3050 GDDR6 8GB, 16GB DDR4 @3200 and a Samsung 980 1TB SSD. All game tests are performed at 1080p at the highest graphical profile.

XPG
SAMSUNG
Solid State Drive
SEAGATE
FIRECUDA
GAMING
PCIe Gen4 SSD
530 Series
XLR8

PCIe 4.0 NVMe M.2
KINGSTON
FURY
RENEGADE
crucial
by Micron
P5 Plus M.2 2280

SO SOLID CREW

Rejoice, for ridiculously quick PCIe Gen 4 drives are now almost mainstream. *Jeremy Laird* chooses from six of the speediest NAND SSDs

IT TOOK ITS MERRY TIME. But with the latest 12th Gen Alder Lake CPU family, Intel can finally support PCIe Express Gen 4 on the desktop. Better 18 months later than AMD and its PCIe 4.0-capable Ryzen 3000 CPUs than never, huh?

Whatever. You now have free reign to build a PC based on a platform from either of the core hardware vendors without worrying about interconnect spec. As for why PCIe 4.0 matters, as ever, it comes down to speed. If you want the fastest connection speed for peripherals, you need PCIe Gen 4. And if there's a single component that benefits most from more PCIe bandwidth, it's storage.

Gen 4 doubles theoretical bandwidth over Gen 3 to fully 8GB/s in both directions. Thanks to AMD's early move in the Gen 4 space, there are already a wealth of PCI Express Gen 4 drives to choose from and several get remarkably close to the full capability of the interconnect.

What's more, SSDs have avoided the debilitating price rises suffered by some PC components over the past year or two. Now, you not only get more speed but also more storage for less money. By CPU and GPU standards, a multi-TB SSD is positively affordable. None of which means, however, that all Gen 4 drives are equal. So, it's time to find out how six of the very best perform.

SPECIFICATIONS

Capacity	1TB
Form factor	M.2 2280
Controller	Micron PCIe Gen 4
Interface	PCIe 4.0 x4
Control protocol	NVMe
Memory type	Micron 176-layer TLC flash
DRAM cache	1GB DDR4
Sequential performance	6,600MB/s read, 5,000MB/s write
Maximum IOPS	630K read, 700K write
Endurance	600TB
Warranty	5 years

Crucial P5 Plus 1TB

JUST NINE DOLLARS. That's how much extra you currently have to pay for the Crucial P5 Plus 1TB with PCIe Gen 4 capability over the older Crucial P5 Gen 3 drive. The plain old P5, should we need to remind you, returns barely more than half the performance by several measures. Even if you don't have a Gen 4 capable rig right now, it surely makes sense to go with the Gen 4 drive and future-proof your storage for any possible CPU and motherboard upgrade.

With that in mind, it's not a huge surprise to find the Crucial P5 Plus is the cheapest drive on test. Less than $130 for 1TB's worth of Gen 4 goodness in an M.2 package? Sign us up! It's not as if this drive cuts any obvious corners in terms of specifications either.

Partly, that's thanks to the fact that Crucial's parent company Micron is one of the world's biggest producers of the NAND flash memory that goes into SSDs. So, it gets access to the latest chips for less cash than the competition.

In this case, we're talking Micron's latest TLC or triple-level-cell flash memory and so none of that clunky, cheap QLC gunk. Micron reckons the new 176-layer NAND chips are a major upgrade over the more familiar 96-layer NAND memory, with lower latency, more throughput, and better endurance.

Of course, it's not just flash memory Crucial does in-house. It has its own SSD controller chips, too, now updated for PCIe 4.0. Crucial hasn't been forthcoming regarding the specs of the new controller, but we know the old Gen 3 model was a six-core chip, so that's likely to be the case again. It certainly has eight memory channels and on this 1TB M.2 drive hooks up to 1GB of DDR4 cache.

Hardware-based AES 256-bit encryption and the obligatory SLC cache mode, which increases performance by allowing a portion of the drive to be dynamically allocated to run in faster single-level-cell mode, are also in the mix. As for write endurance, this 1TB version is rated at 600TB and also covered by a healthy five-year warranty, which should be plenty for all but the most demanding users. In short, there are no obvious omissions, no signs of cutting corners to save costs.

That said, the claimed 6,600MB/s peak read and 5,000MB/s write sequential performance is clearly a little off the pace of the quickest PCIe Gen 4 drives. The same goes for random access performance, which is rated at 630,000 read IOPS and 700,000 write IOPS. Several drives on test this issue are good for one million IOPS, by the official numbers at least. So, something has gone slightly amiss to hit the lower price point.

That carries over to our benchmarks. The P5 Plus proves good for the claimed sequential throughput, though performance in short queue depth 4K random workloads of 69MB/s and 174MB/s for reads and writes is a fair way off the fastest drives. If synthetic benchmarks only tell you so much, the P5 does well in the more real-world PC Mark Storage index, notching up an impressive 3,140 points.

On the subject of sustained performance, throughput drops off consistently after around 300GB of writes, which likely reflects the maximum possible size of the dynamically allocated SLC cache. We also found a brief performance blip after 200GB, possibly due to thermal throttling, the latter arguably confirmed by the fairly toasty peak temp of 69°C under load.

If that's not exactly reassuring, the warranty and Crucial's broader reputation for quality and customer support should do the trick. Technically, then, this isn't the most impressive drive. But it's likely all the SSD you need for a pretty great price.

VERDICT
8

Crucial P5 Plus 1TB

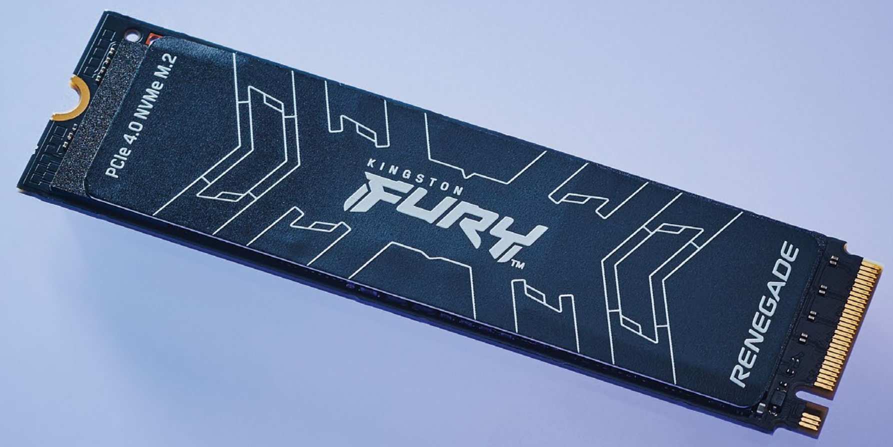
⊞ **KINDA CRUCIAL** Hardly a slouch; five-year warranty.

⊟ **COME AGAIN?** 4K performance unspectacular; runs pretty warm.

$128, www.crucial.com

SPECIFICATIONS

Capacity	2TB
Form factor	M.2 2280
Controller	Phison PS5018-E18
Interface	PCIe 4.0 x4
Control protocol	NVMe
Memory type	Micron 176-layer TLC flash
DRAM cache	2GB DDR4
Sequential performance	7,300MB/s read, 7,000MB/s write
Maximum IOPS	One million
Endurance	2,000TB
Warranty	5 years



Kingston Fury Renegade 2TB

AS A MEASURE of just how successful the Phison E18 PCIe Gen 4 controller chip for SSDs has become, consider that the Kingston Fury Renegade 2TB isn't even alone among Kingston's M.2 drives in using it. The Kingston KC3000 also packs the E18 controller.

Among the SSDs tested this issue, you can also add the PNY XLR8 CS3140 and Seagate Firecuda 530 to the list of E18 groupies. All of which begs the question why? What is it that makes the E18 so popular? The Phison PS5018-E18, to use its full nomenclature, is an eight-channel controller produced on TSMC's 12nm process. It comes configured with five CPU cores in total, three of which use ARM's Cortex R5 IP with the remaining two designed by Phison itself.

All told, Phison reckons the E18 is good for 7.4GB/s sequential read performance and 7GB/s writes, plus the minor matter of one million IOPS. Those sequential numbers aren't far off the peak 8GB/s theoretical throughput of a quad-lane PCIe 4.0 M.2 interface, which this and every other SSD this month use. So, it's a pretty serious bit of kit.

As it happens, Kingston's specs for this implementation of the E18 mostly align with Phison's. Peak reads for this 2TB version of the Fury Renegade are rated at 7,300MB/s, with the full 7,000MB/s for writes and once again one million claimed IOPS. Controller aside, Kingston says the Fury Renegade uses TLC NAND without going into specifics.

However, we're pretty confident it uses Micron's latest 176-layer chips. And that's a good thing. We say that without peeling off the thin aluminum heat spreader. It would be a pity to do that, what with its fancy layer of graphene for optimized thermal conductivity.

Intriguingly, the Fury Renegade drive actually has slightly less usable space at any given capacity compared with its KC3000 Kingston sibling. That enables greater redundancy provision for the Fury Renegade and in turn superior write endurance. The 2TB KC3000 is rated at 1,600TB of writes, but the 2TB Fury Renegade achieves a fairly epic 2,000TB. Of course, hardly anyone is going to run into the 1,600TB wall in the real world. But endurance to spare is always reassuring, especially for the long haul.

Speaking of provisioning, this drive also had a healthy allocation of high-performance SLC cache. Peak sustained performance is maintained for fully 700GB before the SLC cache runs out and the underlying performance of the TLC chips is exposed. That's a lot of data to be getting on with and means that this drive will rarely fall back on TLC as opposed to SLC performance.

Inevitably, there's a fair amount of overlap among Phison-powered drives when it comes to performance. You'd struggle to squeeze a cigarette paper between the Fury and the Seagate Firecuda 530 when it comes to peak sequential performance, even if it's actually the XPG Gammix S70 that knocks out the highest read speeds of all.

As for 4K random access performance, it's a similar story here, too. The Fury is up there with the best. It also cranked out a particularly good result in PCMark 10's full drive test, topping the tables with 3,177 points.

Just as impressive, this drive runs nice and cool despite lacking a fat heatsink. Our peak measured temperature of 44°C makes it unlikely you'll ever run into problems with thermal throttling. It also bodes well for longevity in terms of reduced thermal stress on the drive's PCB. All of which means this is a good SSD with just one problem. Like the other Phison-powered 2TB drive, the Seagate Firecuda 530, it's hellishly pricey.

VERDICT

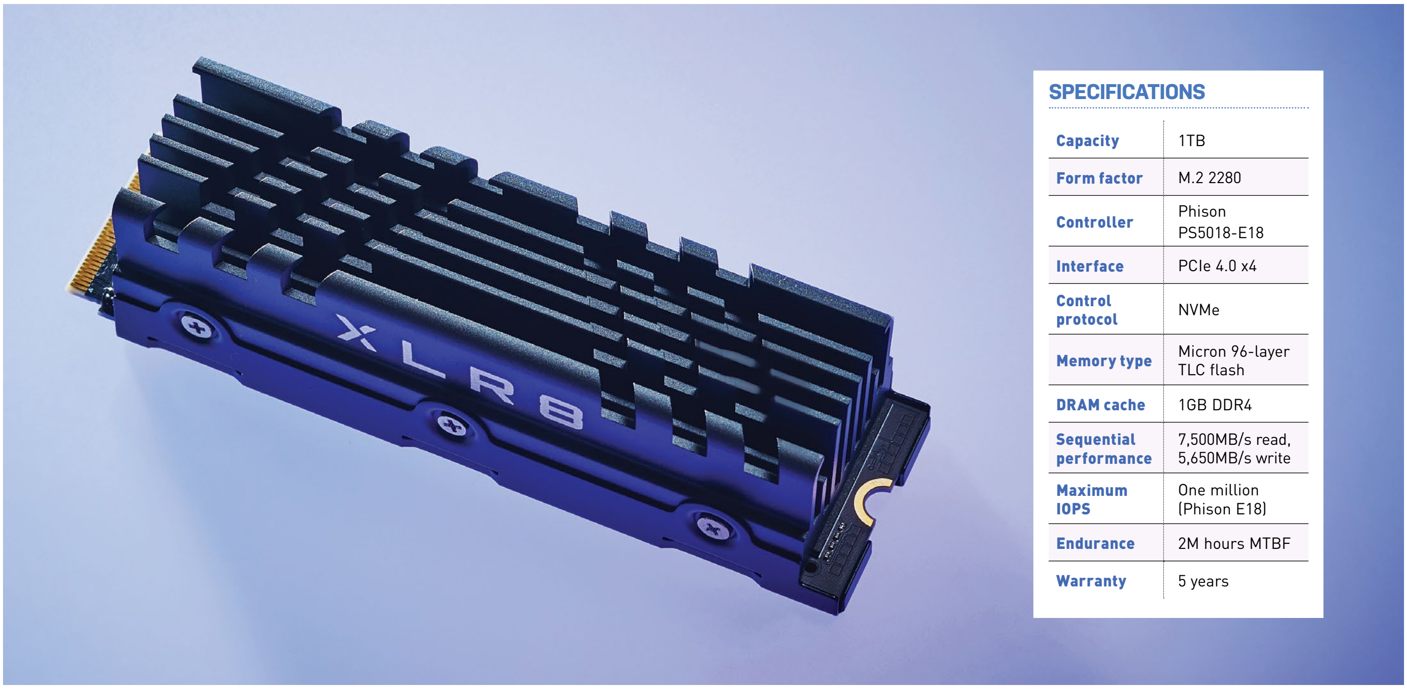
8

Kingston Fury Renegade 2TB

+ FURIOUS SPEED Awesome all-round performance; epic endurance.

− PLAIN OLD ANGRY So very expensive; 4K throughput is nothing special.

$353, www.kingston.com



SPECIFICATIONS

Capacity	1TB
Form factor	M.2 2280
Controller	Phison PS5018-E18
Interface	PCIe 4.0 x4
Control protocol	NVMe
Memory type	Micron 96-layer TLC flash
DRAM cache	1GB DDR4
Sequential performance	7,500MB/s read, 5,650MB/s write
Maximum IOPS	One million (Phison E18)
Endurance	2M hours MTBF
Warranty	5 years

PNY XLR8 CS3140 1TB

GIVE IT UP FOR our second Phison E18-based drive, the PNY XLR8 CS3140. Handily, we have the PNY in 1TB format, allowing a look at both 1TB and 2TB drives with the controller du jour for drive integrators who don't have the desire or means to do one in-house.

PNY is pretty punchy about the performance of this drive, claiming an eye-popping 7,500MB/s per second for sequential read performance, which is as fast as we can recall for a single consumer NAND-based SSD. For what it's worth, that figure is also higher than the supposed maximum speed Phison claims for the E18 controller used by the CS3140. Make of that what you will.

Inevitably, writes are a little tardier at 5,650MB/s, which is actually in excess of 1GB/s slower than the 2TB variant of the CS3140. PNY doesn't exactly share when it comes to details like maximum IOPS performance or the identity of the NAND chips it uses. The former is largely a known quantity thanks to the Phison controller and with a little digging around, the latter is revealed to be Micron's 96-layer TLC rather than its latest 176-layer chips. Perhaps that aspect can change, hence PNY prefers not to tie the spec sheet to a particular NAND spec.

If that's all fine, it is annoying that PNY doesn't quote write endurance, opting to provide an MTBF or mean time before failure rating of two million hours. In our view, that's fairly meaningless. You'd expect an SSD sitting around doing not much to last a long time, while a drive handling loads of write and erase traffic might tank relatively quickly.

Still, with the Phison controller, Micron NAND chips, a five-year warranty, and nice cool running (more on that later), it's not like we're actually concerned about longevity. We'd just prefer more clarity.

All that aside, this 1TB model of the PNY XLR8 CS3140 gets 1GB of DDR4 cache memory, plus the minor matter of a fat heatsink. Ostensibly, that bodes well for thermals. The complication is that many motherboards integrate their own heat spreaders, making the chunk of metal on the CS3140 arguably redundant.

Before anyone suggests it, however, this particular heatsink is not a sop for Sony PS5 owners—as is the case with so many SSDs of late, including the newly-tweaked Samsung 980 Pro Heatsink. As it happens, PNY's cooler is twice as thick as the maximum specifications for that console, so it's a non-starter.

As motherboard-based SSD cooling solutions vary, it's not at all straightforward to determine whether PNY's heatsink solution will be better or worse by comparison. What we can say, however, is that not only does the PNY CS3140 run cooler than the other Phison-based drives, it's the coolest customer of all six SSDs here.

Anyway, in terms of tested performance peak throughput is a little less than we'd hoped for at a little over 7GB/s for reads and around 5.2GB/s for writes. The drive's 4K sequential reads come in at 72MB/s, which again is slightly off the pace. Both the Samsung and the other Phison drives crack the 80MB/s barrier.

Meanwhile, if you are wondering how much of the main NAND memory PNY allows for high-performance SLC cache, our testing indicates the dynamic allocation can go as high as 300GB, which should be enough for most needs.

For the record, you can have the PNY XLR8 CS3140 without the beefy heatsink, but it's barely any cheaper than this variant. So, it doesn't fix this drive's main problem, which is the price tag. It's a good SSD—just that you can have something else just as good for quite a bit less cash.

VERDICT **7**

PNY XLR8 CS3140 1TB

+ **XLR-GREAT** Great performance; runs super cool.

− **PN WHY, OH WHY** Like all Phison drives, it's awfully expensive.

$145, www.pny.com

SPECIFICATIONS

Capacity	2TB
Form factor	M.2 2280
Controller	Phison PS5018-E18
Interface	PCIe 4.0 x4
Control protocol	NVMe
Memory type	Micron 176-layer TLC flash
DRAM cache	2GB DDR4
Sequential performance	7,300MB/s read, 6,900MB/s write
Maximum IOPS	One million
Endurance	2,550TB
Warranty	5 years

FIRECUDA
GAMING
530 Series
PCIe Gen4 SSD
SEAGATE

Seagate FireCuda 530 2TB

FUNNY OLD THING, the storage market. You might have expected the traditional magnetic drive outfits to pile heavily into solid-state storage. After all, the writing isn't just on the wall for those magnetic platters, it's burned right into their spinning surfaces. It's not that the future is solid-state, the shift has already happened.

Until now, the exception has been WD, with the SN850 Black being a particular success and one of the best of the current generation of PCIe Gen 4 drives (read about the SN850 at the end of the group test). But Seagate? While it has been active in the SSD market, it hasn't exactly made headlines.

That deserves to change with the new Seagate FireCuda 530 2TB. It's a very good drive. Surprisingly, given Seagate's status as a long-time big hitter in the storage market, this M.2 drive uses, yes you guessed it, the Phison E18 controller. Just like the PNY XLR8 CS3140 and Kingston Fury Renegade, not to mention numerous other drives on the market. Pretty much every Phison-based drive we've tested flies. So, that's got to be a good thing.

As for NAND flash memory specification, Seagate has likewise gone for Micron's latest 176-layer TLC NAND memory. Micron reckons it's quicker, denser, and more durable than its existing 96-layer memory chips. In our experience, the 176-layer stuff is up there with the very best. This is also the 2TB configuration of the FireCuda 530, so it gets 2GB of DDR4 cache. For headline performance, Seagate claims 7,300MB/s for peak reads and 6,900MB/s for writes. So far, then, this all feels like a fairly familiar, if impressive, recipe.

If there is an exception to the identikit spec list, it involves write endurance. Seagate rates the 2TB model of the FireCuda 530 as good for 2,550TB of writes, which is moderately staggering. We suspect Seagate has used its undoubted experience and engineering nous to tweak the Phison E18's firmware to allow for a bit more endurance than the direct competition.

Whatever, it's hardly a shock to find this drive knocks out numbers not dissimilar to other Phison-based Gen 4 M.2 SSDs. Indeed, for sequential reads and writes, it's essentially indistinguishable from the Kingston Fury Renegade 2TB. Which is to say it's fast, seriously fast. Only the XPG Gammix S70 2TB is quicker in terms of reads, but not by all that much.

Also in line with other Phison drives is the 4K random access performance, with 83MB/s reads and 251MB/s writes. All the while, this thing keeps impressively cool, maxing out at 41°C. That's especially good considering this drive doesn't have a heat sink. If you're wondering about sustained performance and the size of the FireCuda 530's SLC cache, we found full performance is maintained for at least 700GB of writes, which has to be enough for just about any realistic workload.

Add it all up and you have a speedy, cool-running drive. There isn't much that's tangibly quicker out there on the market, something you can of course say about most Phison E18-based M.2 Gen 4 SSDs. The other thing you can say about this SSD, along with its Phison pals, is that it's pricey. It's a legitimate question to ask if you can feel the difference compared to cheaper and ultimately only slightly slower drives.

That said, the FireCuda 530 arguably has a trump card that places it apart from its direct competitors. As hinted by the exceptional endurance rating, if our lives depended on one of the Phison drives here outlasting the others, we'd choose this Seagate drive and the reputation and experience that comes with one of the best-known brands in storage.

VERDICT
8

Seagate FireCuda 530 2TB

⊞ **ON FIRE** Seriously speedy all-round performance; staggering endurance.

⊟ **BURNED OUT** It's that little matter of money, it costs so much!

$359, www.seagate.com

SAMSUNG
Solid State Drive

SPECIFICATIONS

Capacity	1TB
Form factor	M.2 2280
Controller	Samsung Elpis
Interface	PCIe 4.0 x4
Control protocol	NVMe
Memory type	Samsung 128-layer TLC flash
DRAM cache	1GB DDR4
Sequential performance	7,000MB/s read, 5,000MB/s write
Maximum IOPS	One million
Endurance	600TB
Warranty	5 years

Samsung 980 Pro Heatsink 1TB

FOR AN AWFULLY long time, Samsung was the gold standard when it came to SSDs. Year after year, when Samsung released its latest premium SSD, it went straight to the top of the performance tables. It was a textbook example of how the sheer engineering might of one of the world's biggest tech companies made for a competitive advantage.

Funnily enough, that was still pretty much the case when Samsung wheeled out the standard 980 Pro. And this 980 Pro Heatsink 1TB is largely the same drive. So, that makes it a nailed-on certainty for the win, right? Actually, no. The problem is that the 980 Pro was launched way back in the Fall of 2020. The market has since moved on and the 980 Pro has been marginally overtaken.

The big news with this iteration of the 980 Pro is the heatsink. Samsung says the heatsink has been optimized courtesy of "data center technology" to dissipate heat efficiently from the controller chip, which is, of course, Samsung's own design.

If that sounds a bit like marketing fluff, then what we can say for certain is that the heatsink takes this M.2 drive's thickness to 8.5mm. Not at all coincidentally, that makes it fully compatible with the Sony PS5 game console, which is really why this new variant exists. As for how much sense it makes on the PC, we'll come to momentarily.

Beyond that, there's little else new to report, the tech specs are the same as at launch 18 months ago. That doesn't mean this SSD is totally outclassed, however. Far from it. You get 1GB of DDR4 cache, a five-year warranty, and, of course, Samsung's own high-quality TLC NAND memory. More to the point, this is still a cutting-edge PCIe Gen 4 drive with pretty stellar read and write speeds of 7GB/s and 5GB/s respectively. Samsung also says it will do no fewer than one million IOPS, which is as good as any NAND-based SSD we know of.

Not as impressive is the maximum 144GB of space the drive can allocate to operate in speedy SLC mode. Notably, that's less than the two other 1TB drives here, which both allocate up to 300GB. How much that will actually matter in practice is debatable. Arguably, most users will find that 144GB is plenty for sustained performance. But it can't be totally ignored.

In any case, our testing confirms that sustained throughput does indeed drop after roughly 140GB of sustained writes. As for operating temperatures, we registered a peak of 53°C sustained load, which is just fine for both sustained performance and overall longevity.

By other performance metrics, this slight tweak to the existing Samsung 980 Pro is unsurprisingly a dead ringer for the original. So, it's a very quick SSD, but not quite as speedy as most of the newer PCIe 4.0 M.2 drives in this group. 6.7GB/s reads and 4.9GB/s writes are nice numbers in isolation. But the fact is they are bested, even by the Crucial P5 Plus, which is a cheaper drive positioned in a more mainstream part of the market.

Of course, some would argue that such measures of peak sequential performance are somewhat academic in the real world. Once you've got several GB/s of throughput, the details don't matter that much.

Even if that is true, the 980 Pro is still behind when you factor in 4K random access. 4K write performance of 200MB/s is particularly weak compared to all but the Crucial P5 Plus.

All of that would actually be fine were it not for one small snag. The 980 Pro Heartsink is priced like it's right at the top of the performance tree. But it isn't, not quite. So, for that reason alone, it's hard to recommend for the PC.

VERDICT 7

Samsung 980 Pro Heatsink 1TB

+ RETURN OF THE KING Still has strong all-round performance; Samsung brand is reassuring.

− MOUNT DOOM Slightly disappointing 4K writes; not cheap enough.

$166, www.samsung.com

SPECIFICATIONS

Capacity	2TB
Form factor	M.2 2280
Controller	InnoGrit IG5236
Interface	PCIe 4.0 x4
Control protocol	NVMe
Memory type	Micron 96-layer TLC flash
DRAM cache	2GB DDR4
Sequential performance	7,400MB/s read, 6,800MB/s write
Maximum IOPS	650K read, 740K write
Endurance	1,480TB
Warranty	5 years

XPG Gammix S70 2TB

JUST WHEN you were beginning to think that Phison had a complete stranglehold on the third-party SSD controller market, here comes the XPG Gammix S70 to blow that notion away. Lift this M.2 drive's beefy alloy lid and you'll find none other than an InnoGrit IG5236 chip, which is somewhat intriguing.

So, what can we tell you about the InnoGrit IG5236? It's a multi-core controller with NVMe 1.4 support, eight memory channels, and a quad-lane PCIe 4.0 interface. Like the Phison E18, it's built on TSMC's 12nm FinFET process, which bodes well for things like clockspeeds, thermals, and efficiency.

Of course, merely being novel isn't going to cut it. Nor is multiple gigabytes of bandwidth in each direction. The SSD market is thick with PCIe Gen 4 drives that can hammer out huge numbers.

That said, the headline speeds do look pretty decent, what with 7,400MB/s claimed reads and 6,800MB/s writes. What's more, the InnoGrit chip supports both SLC caching and DRAM cache.

In this implementation, you get 666GB of SLC cache and 2GB of DDR4 DRAM cache. All thoroughly competitive, if a little devilish, so far.

If it's chinks in the armor you seek, however, there are a few. For starters, the drive's peak IOPS are quoted at 650K for reads and 740K for writes. That's a little off the one-million-IOPS pace set by several drives here. Similarly, the 1,480TB of claimed write endurance is fully 1,000TB behind the very best.

In both cases, you could argue that kind of on-paper comparison doesn't mean much in the real world. That's especially true of the write endurance rating. Do the math and it works out to 810GB of writes each and every day for no fewer than five years. That's gotta be enough for almost anyone. Speaking of five years being enough, that's how long the warranty is, too.

While we're having a go, you could also argue that the Gammix S70's NAND chips are a little old hat, too, being Micron's 96-layer TLC output rather than the very latest 176-layer items. But what really matters is how this thing performs—and the XPG's performance can be reasonably described as pretty stellar.

How so? Well, it's the fastest drive here by several metrics. It has comfortably the quickest sequential read speed at 7,451MB/s, while its sequential writes are only a little off the pace at 6,793.

Arguably even more impressive is the S70's 4K random write performance, given 4K throughput is both so much harder to achieve than sequential and arguably has more impact on the actual feel of your PC. At 262MB/s, it's the quickest on test.

Just a little less impressive is the 4K read result of 74MB/s. 2,879 points in PC Mark's storage test doesn't exactly set the benchmark table alight, either. The operating temperature under load of 67°C is arguably a little warmer than we'd like, too, especially considering that big heatsink.

So, this drive is a very strong, but not quite flawless performer. If the only metrics that mattered were pure performance and anticipated longevity, the XPG Gammix S70 would be a decent contender for your money, but probably not an outright winner. But there's one more dimension to consider. And that's the price.

At pretty much $100 less than the other two 2TB drives on test, this SSD represents outstanding value. Money no object, we'd go for the Seagate drive. However, money is an object for most people, including us.

If the price is a consideration for you, too, the Gammix S70 is easily close enough to the Seagate in every other regard for its reasonable price tag to push it over the line.

VERDICT 9

XPG Gammix S70 2TB

+ TRUE GRIT Strong performance in many metrics; stellar value for money.

− A LITTLE BIT SHI... 4K reads not all that; runs just a little too warm.

$259, www.xpg.com

THE FINAL RECKONING

SIX SPEEDY M.2 SSDS. A zillion benchmarks. And a whole hill of specs. But what have we learned? Firstly, the quality of current SSDs is very high. There absolutely isn't a dud here. Every single drive would be an electrifying upgrade for a system based on something like an old SATA SSD. Indeed, it's remarkable to think 7GB-plus per second of bandwidth is rapidly becoming the norm. You don't have to be as old as Ulysses S. Grant to remember when that kind of bandwidth was decent for a CPU, let alone storage.

If there is a disappointment it involves 4K random access performance. It's those tiny little data requests and writes that can make the difference to how snappy your PC feels in regular use. While random access throughput has improved thanks to a big uptick in IOPS or Input Output Operations performance, 4K performance is still miles off sequential throughput and not progressing at the same pace. To put that into numbers, these PCIe 4.0 drives are well over ten times faster for sequential performance than a good SATA SSD, but more like three to four times quicker for 4K throughput.

And remember, the arrival of PCI Express 5.0 drives won't automatically do anything to change that. Intel's Alder Lake CPUs already have PCIe Gen 5 support and AMD is expected to add it when the new Ryzen 7000 chips appear later this year. But all Gen 5 will guarantee is increased headroom for double the maximum theoretical throughput. OK, 16GB/s of potential storage bandwidth sounds bonkers. But we'd rather see the 4K grunt increased, given the choice.

Another issue worth noting is that SSD performance arguably doesn't have a huge impact on game level load times, as our *Final Fantasy XIV: Shadowbringers* benchmark results show.

Indeed, a certain well-known YouTuber recently lined up a row of PCs running games courtesy of everything from an old SATA SSD to the latest and greatest NVMe M.2 drive. In a blind test, it was clear that nobody could reliably identify what was ostensibly the much faster storage subsystem.

The caveat to that is the possible impact of Direct Storage, a technology first seen on the Xbox Series X and due on the PC imminently. The details of how it works are a story for another day. But it could make really high-performance storage far more important for PC gaming than ever before.

That aside, the gaming thing just serves to underline how important value is. In subjective terms, we think it would be a struggle to tell any of these drives apart, day to day, for almost any task, not just gaming. They are all very quick SSDs with quality TLC NAND, not nasty QLC stuff, eight memory channels, quad PCIe 4.0 lanes, plenty of DRAM cache, all the good stuff.

With that in mind, price matters an awful lot. That's why the XPG Gammix S70 2TB impresses so much. $259 isn't throwaway money. But you get so much for it, namely 2TB of seriously fast storage. Not only does it make the more expensive competition look largely redundant. It makes current graphics card pricing seem positively insane.

We can remember way back to the early days of solid-state storage on the PC, to playing with stuttering pre-TRIM Intel drives measuring a few tens of GB and wondering when it might be affordable to have lightning-fast solid-state drives for mass storage. That day has surely come with the likes of the XPG Gammix S70. Genuinely affordable and stupidly quick, it's all the SSD almost anyone could ask for.

BENCHMARKS

		Synthetic performance - ATTO Disk Benchmark		PCMark10 Storage (full)		
	Maximum PC overall rank	Peak Sequential Read (MB/s)	Peak Sequential Write (MB/s)	Index	Bandwidth (MB/s)	Average Access Time (μs)
Crucial P5 Plus 1TB	4	6,390	4,660	3,140	498	53
Kingston Fury Renegade 2TB	3	6,860	6,440	3,177	510	53
PNY XLR8 CS3140 1TB	5	6,820	4,890	2,683	409	72
Samsung 980 Pro Heatsink 1TB	6	6,230	5,080	2,746	431	60
Seagate FireCuda 530 2TB	2	6,940	6,410	3,021	487	56
XPG Gammix S70 2TB	1	6,950	6,340	2,879	458	58

WD'S SN850 BLACK

Not appearing in this Group Test

With any group test, there's always one that got away. That was particularly likely with this gathering of high-performance PCIe Gen 4 M.2 SSDs. After all, the market is positively heaving with options, all of them seriously speedy.

The most conspicuous absence, however, has to be the WD Black SN850. The 2TB version can be had for around $265, which puts it right in the XPG Gammix S70 2TB's wheelhouse. But the SN850 has some conspicuous performance advantages. As you'd expect, it puts out really big sequential numbers. But so do all the other drives.

Instead, it's the trickier—and arguably more critical for that sense of day-to-day response and performance—4K random performance where the WD Black SN850 makes its mark.

In our previous testing, it cranks out a whisker over 90MB/s for reads and well above 300MB/s for writes, which would put it at the top of the table. Notably, it also outscores every drive here in PC Mark's Storage benchmark.

Of course, it does all that while also offering the reassurance of the WD brand, which has been one of the best in the storage business for decades. To be frank, it makes the pricey Phison-based SSDs look a tiny bit silly. It's hard to imagine why you'd pay loads more for one of those when the excellent WD Black can be had for so much less.

It's not perfect, of course. You could argue that its 96-layer SanDisk TLC NAND memory is a little long in the tooth. The SN850 also looks a little off the pace for sequential write performance.

The 2TB model's rated write endurance of 1,200TB is nowhere near the best, either. But then the WD brand is so strong, we'd still have more confidence in the SN850 than some other drives with higher quoted endurance. You have to be in it to win it.

So, the WD Black SN850 might be a sideshow in this test, but it's a pretty compelling sideshow, it has to be said.

Peak Temp	CrystalDiskMark 7.0.0				Final Fantasy XIV: Shadowbringers
Temperature (°C)	SEQ1M Q8T1 Read (MB/s)	SEQ1M Q8T1 Write (MB/s)	RND4k Q1T1 Read (MB/s)	RND4K Q1T1 Write (MB/s)	Total Loading Time (seconds)
69	6,854	5,000	69	174	11.321
44	7,344	6,897	83	247	11.2
36	7,036	5,230	72.2	251	11.6
53	6,668	4,936	86	200	11.3
41	7,334	6,874	83	251	11.4
67	7,451	6,793	74	262	11.4

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ULTIMATE GAMES PREVIEW!

In a sea of new PC games due out in 2022, *Ian Evenden* has picked 35 worth waiting for

NAILING DOWN the games of 2022—what's left of it, at least—proved to be trickier than in previous years. There is a distinct lack of concrete release dates out there, with developers preferring to take an 'it'll be done when it's done' approach instead of killing themselves with 80-hour weeks as they crunch toward an unwise deadline.

And that's just fine. After all, the more game developers who are left alive, the more games we get to play.

There's also a dearth of big names. There's no *Call of Duty* coming out this year. No new *GTA*, unless you count another re-release of *V*. No *Assassin's Creed* nor *Far Cry*. No *Halo*, no *Doom*, no *Civ*... the list of absences goes on.

This leaves room for the other players, at least. We see a great number of new games that aren't sequels, spin-offs, or remakes (though there are still examples of all three) and an awful lot of games with 'TBC' where their release date should be. If this represents a healthy correction for the game industry after years of crunch-based horror stories, then so be it.

Our PCs will be ready when the time comes.

Tiny Tina's Wonderlands

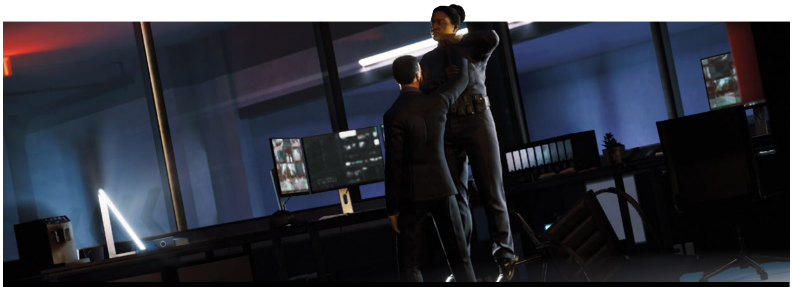
A *Borderlands* spinoff, *Wonderlands* returns to the fantasy role-playing game of Assault on Dragon's Keep for a first-person shooter that can be played solo or in a four-player co-op. There's the usual randomly-generated loot system to ensure interesting new guns keep coming, but while *Borderlands* forced you into pre-existing characters, *Wonderlands* has a looser character generator, with a class system allowing you to put your own stamp on who you are.

- Out: Now
- playwonderlands.2k.com

© 2K GAMES

Lego Star Wars: The Skywalker Saga

Is there anyone who hasn't played this yet? A somewhat repetitive series going since 2005, *The Skywalker Saga* brings together Lego versions of all nine *Star Wars* films into the best Lego game experience since the last one. The big change this time is that it's more of a third-person shooter than before, with a shiny graphical overhaul. The floaty movement of the original games has gone, replaced by clever environmental effects such as Han Solo's aimed shots and the protocol droids' ability to score side missions.
- Out: Now
- www.starwars.com/games-apps/lego-star-wars-the-skywalker-saga



Vampire: The Masquerade – Swansong

A narrative RPG rather than an out-and-out throat-ripper, you're given control of three vampire characters who are often surrounded by humans. Despite this, they need to upgrade their supernatural powers and make moral choices in situations where there's no obvious right answer. Each character has different views on how best to hide themselves from humanity, leading to more problems for the player to solve. Despite being based on the fifth edition of the *Vampire: The Masquerade* tabletop RPG, you don't need to have played that game, or the *Bloodlines* videogames, to get stuck into *Swansong*. **Out: May 19 • vampire-swansong.com**

S.T.A.L.K.E.R. 2: Heart of Chornobyl

Knowing *STALKER*, the heart of the title may be literal, a giant organ hanging from an irradiated tree, pumping nuclear fuel into countless zombies. Or it might be a metaphor. Who knows? On paper, this sounds like a rehash of the first game, as brave souls make their way to the exclusion zone in the hope of recovering priceless artifacts and not being eaten by horrible monsters. Enough time has passed since the last game, however, for the developers to have learned a new trick or two, so we suspect this cross between an FPS, horror game, and immersive sim may have plenty of surprises as its non-linear story makes its way toward one of several potential endings.
- Out: December 8 • www. stalker2.com

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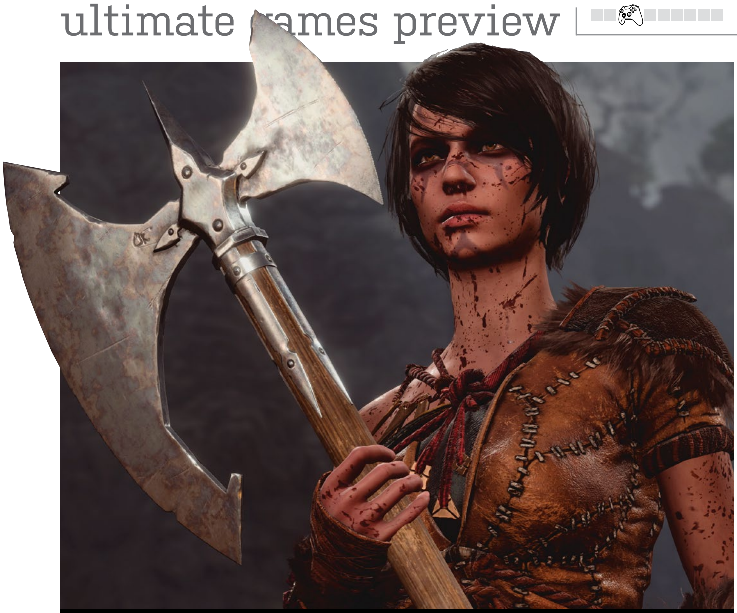

Baldur's Gate 3

Wait a moment *Maximum PC*, you chumps—you've already reviewed this one! Yes, we have, but that was at the beginning of its early-access journey and it's a different game now. For a start, there are more classes, with the new Barbarian rounding out the options with the strength-based build it's been missing. There are improvised weapons, extra magical items, co-op, and—can you believe it—the chicken sound effects have been improved! It's still not finished, so while we might not see it this year, getting it right is more important than getting it soon.
• Out: Now (early access) • baldursgate3.game

Ghostwire Tokyo

Tokyo is overrun with supernatural forces and, apparently, the only way to defeat them is to shoot them in the face. With a helpful spirit sharing your body and elemental spells at your fingertips, you find yourself battling ghosts through a beautifully rendered abandoned Tokyo full of neon and reflections in an attempt to rescue your sister. Expect headless young men in school uniform, the spirits of exhausted businessmen constantly sheltering under umbrellas, and a generally spooky experience.
• Out: Now • bethesda.net/en/game/ghostwire-tokyo

Suicide Squad: Kill The Justice League

A "genre-defying action-adventure third-person shooter", apparently, which makes as much sense as any of the movies did. *Kill The Justice League* is from Rocksteady, the makers of the *Batman Arkham* games. A team of villains with bombs in their heads is sent into an open-world Metropolis to take down Batman, Aquaman, and pals, for reasons we're expecting to require significant mental gymnastics to fully understand. There's co-op and Rocksteady has a certain amount of experience at this sort of thing, so we're cautiously optimistic that this might be a blast. As we went to press, this was sadly delayed to 2023.
• Out: TBC
• suicidesquadgame.com

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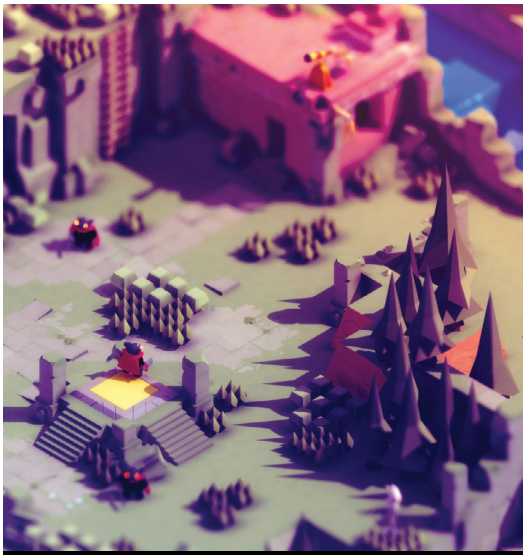

Tunic

A cute adventure starring a fox, *Tunic* has more of a hint of Nintendo's *Zelda* games. The green-clad vulpine explores a papercraft world with a sword and shield, bombs, and a magic staff, while looting treasure chests and exploring caves. There's an old-school attitude to go with the 16-bit visuals, expressed in the way you're left to figure out the in-game language. *Tunic* is charming, good-looking, and on Game Pass.
• Out: Now • tunicgame.com

Uncharted: Legacy of Thieves Collection

We already have one mass-murdering treasure hunter on PC in the form of Lara Croft, so why not add another? Nathan Drake and romantic interest Chloe Fraser have been shooting goons, looting ancient treasures, and wisecracking their way across PlayStation consoles for a long time but, like so many of his formerly exclusive stablemates, they are now coming to PC. The *Uncharted* games are fun third-person adventures in the Indiana Jones mold, and this collection bundles *Uncharted 4* with *Lost Legacy*, a game in which Chloe takes the lead. If you want to play the older ones, better buy a PlayStation.
• Out: Early 2022
• www.playstation.com/en-us/games/uncharted-legacy-of-thieves-collection

Redfall

Arkane, meet vampires. Redfall is a town overrun by neck-suckers, and the game looks very much like an open-world co-op FPS. All we really know comes from one E3 2021 trailer, however, so much could change. Four characters are available: a paranormal investigator with 'inventions', a mysterious telekinetic, an ex-military sharpshooter, and a combat engineer accompanied by a robot. Being Arkane, we expect particularly tight integration between the vampire hunters' powers and the town itself, while the vampires themselves (who won't be the only antagonists) sound more like *Left 4 Dead*'s zombies—fast and aggressive with a scattering of specialized types to give you trouble.
• Out: Summer
• bethesda.net/en/game/redfall

A Plague Tale: Requiem

The sequel to 2019's bucolic survival game notable for its incredible swarms of rats, *Requiem* recently saw its Xbox achievements list leak, which suggests a release could be around the corner. The struggle for survival sees returning protagonists Amica and Hugo travel to a new city on a new continent, where they find the same rats, in the hopes of discovering a prophesied island that may be the key to breaking Hugo's curse. We're promised heart-rending decisions, death and destruction, and a variety of weapons and unearthly powers. And rats.
• Out: TBC • www.focus-home.com

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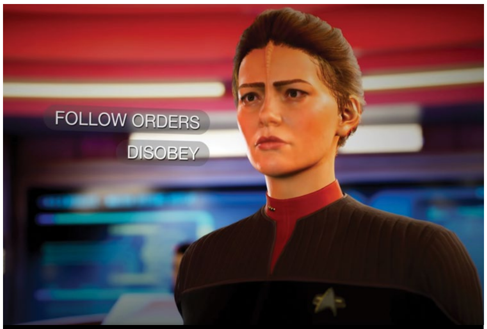
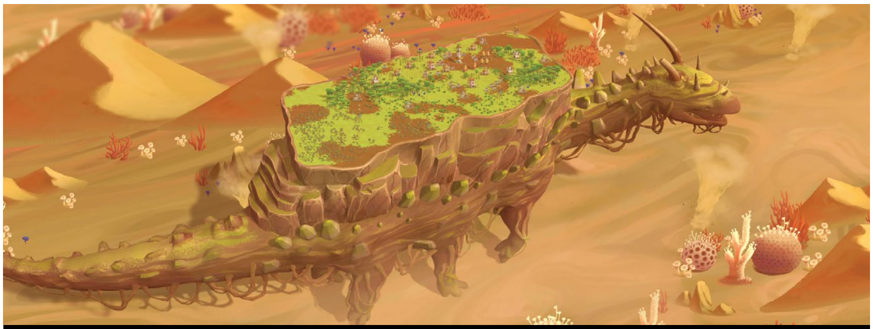


Star Trek: Resurgence

A narrative adventure and RPG, *Resurgence* is set in 2380, after the *Next Generation* movies. Seen from the perspective of the first officer and engineer, there's a mystery to solve before two civilizations go to war.

- **Out: Spring**
- **www.startrek-resurgence.com**



The Wandering Village

As if building a new settlement to save humanity from toxic alien plants wasn't bad enough, try doing it on the back of a gigantic dinosaur-like creature. Obnu, the giant creature you're living upon, can either become your friend or you can be a parasite for the benefit of your population. The post-apocalyptic world your ambulatory settlement stomps through consists of various biomes, and ancient technology can be scavenged from the ruins to improve your lives. Or not, as the case may be.

- **Out: Summer 2022** • **thewanderingvillage.com**

Dune: Spice Wars

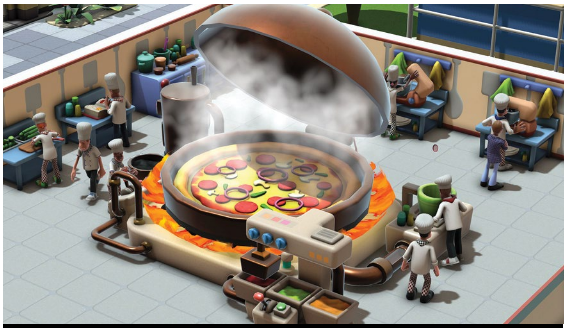
RTS meets political maneuvering is the sell—and we're sold. It's a 4X set on Arrakis, but with a galaxy of political intrigue to back it up and you can play as House Atreides. The dev's previous game was *Northgard*, in which controlling specific territories was more important than dominating the map, while the desert acts like an ocean, requiring specialized equipment to cross. The goal is to be appointed governor of the planet, but an aggressive military strategy makes this more difficult. Striking a balance between war, spice production and diplomacy will win the day.

- **Out: TBC** • **www.dunegames.com**

Forspoken

Delayed from its original May release, *Forspoken* is Square Enix's latest action RPG. A New York woman is flung into a fantasy world of dragons and magic, and learns to use her powers of combat to traverse the difficult terrain—magical parkour, basically. There are plenty of undead to deal with and the world is being consumed by a corrupting fog. Presumably, it's up to her to sort it out, but we wouldn't bet against her cat having a role too.

- **Out: October 11** • **forspoken.square-enix-games.com**



Two Point Campus

The sequel to *Two Point Hospital*, *Campus* has you building a college. Whether you choose modern steel and glass or an ancient castle, the students have the time of their lives with courses such as knight school and gastronomy class. Professors are eccentric, and each student has a personality to be nurtured.

- **Out: May 17** • **www.twopointcampus.com**

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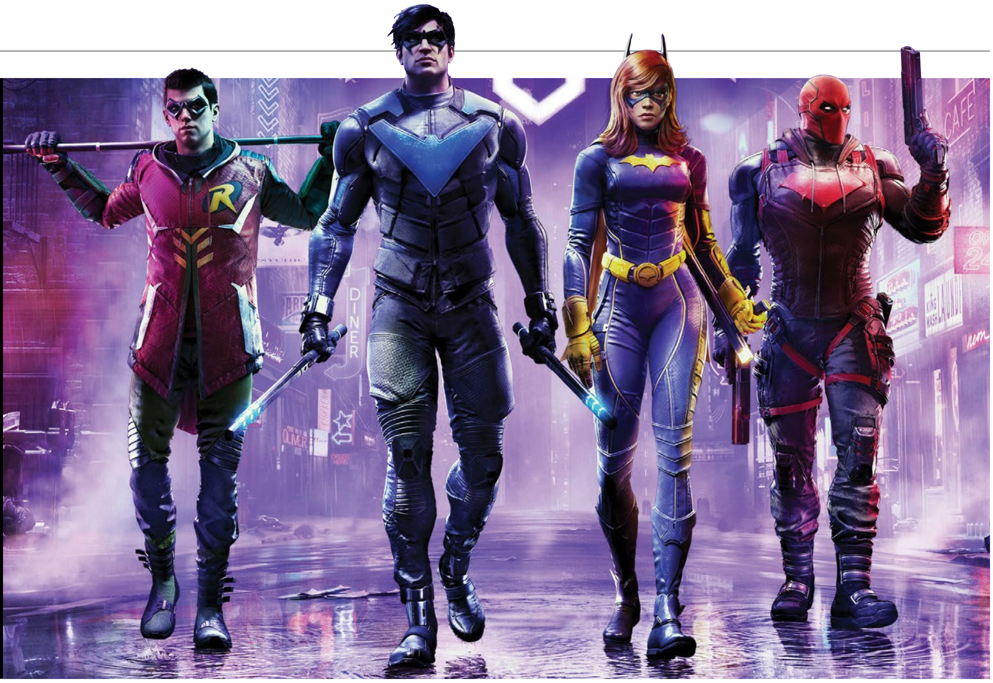
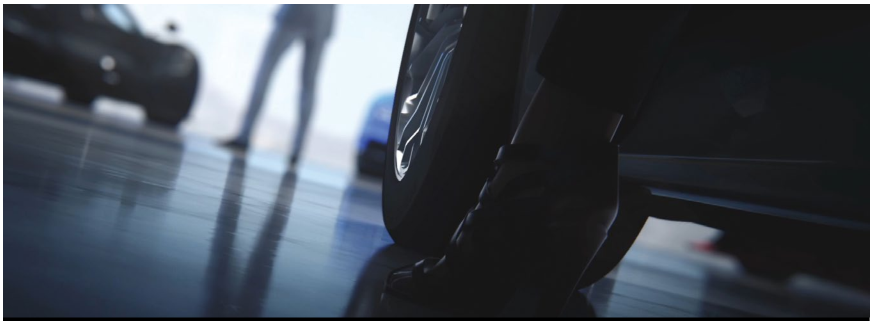
Gotham Knights

'Batman is dead' is a great way to begin a game (was it the Suicide Squad?), and *Gotham Knights* does that before introducing the cast. Not the DC beat 'em up you'd expect, this is an open-world action RPG starring Batgirl, Nightwing, Red Hood, and Robin doing what Batman no longer can, catching criminals and cleaning up the streets of Gotham City. There's a two-player co-op on offer, and we can expect a few recognizable villains, although as some of the heroes are DC deep cuts, it would be good to wipe the smirk off a few unfamiliar faces too.

- **Out: TBC**
- **www.gothamknightsgame.com**





Test Drive Unlimited Solar Crown

Open-world driving in a recreation of Hong Kong, *Solar Crown* is as much about looking good as it is moving fast. Of the few press screenshots available, one is of a cufflink and the others are somewhat lacking in pictures of cars, which should tell you something. Ferrari, Lamborghini, Porsche, Koenigsegg, Apollo, Dodge, and Bugatti are all confirmed to appear, and in a game where social status is everything, the car you drive will say as much about you as how you drive it.

• **Out: September 22** • **www.testdriveunlimited.gg**

Company Of Heroes 3

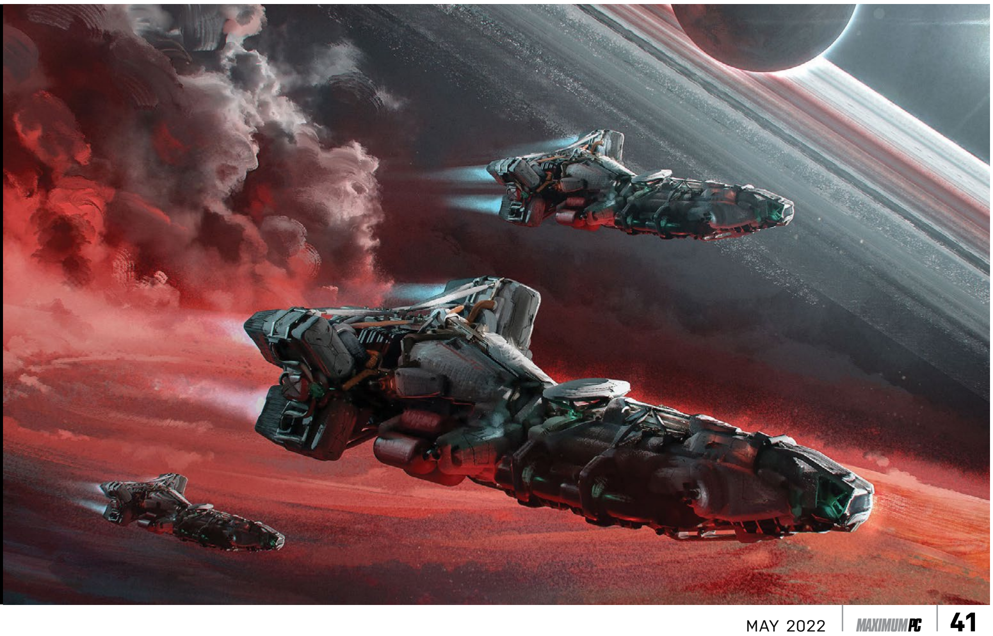
Whatever happened to WWII strategy games? *Company of Heroes 3* offers the series' biggest single-player campaign and a dynamic, sandbox-style map allowing generals to see a full strategic overview before diving into street-level tactics.

• **Out: TBC** • **companyofheroes.com**

Starfield

Bethesda's first new setting in 25 years sees the studio behind *Skyrim* and *Fallout* take to the stars. It's the 24th century, with spaceships and alien predators, and a 50-lightyear radius around Earth settled by humanity, which is split into two major factions. The general idea seems to be '*Skyrim* in space' and, while that would be disappointing on its own, it's not a bad place to start. Add to this pirates, mercenaries, religious zealots, and the aftermath of a major war, plus a pleasure dome where you can get high on alien fish. It can't come soon enough.

- **Out: November 11**
- **bethesda.net/en/game/starfield**



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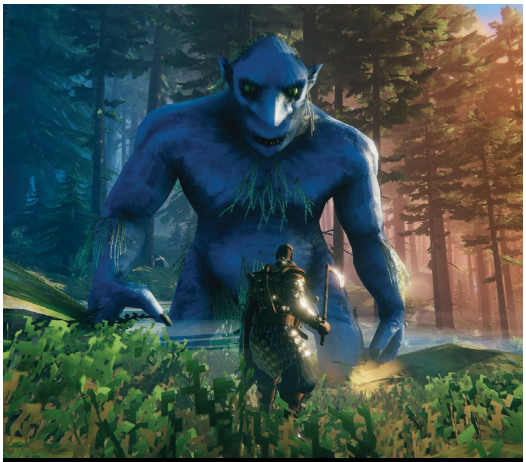
The Lord of the Rings: Gollum

An unusual choice of hero makes for an unusual game. Focused on stealth, with plenty of climbing, platforming, and eating things raw and wriggling, *Gollum* is another casualty of the spate of game delays in 2021. Both Gollum and Smeagol exist in the titular creature's head as he chases the Precious, and the choices you make determine how much of each is left by the time you get to the end. Gollum isn't much of a fighter, so he'll dispose of those in his way through either environmental means or a bit of light assassination when their back is turned, while tough spots are simply avoided by leaping or grappling to a more advantageous position.
• Out: TBC • www.daedalic.com

Saints Row

A full reboot of the long-running series, we don't expect much will change for the anarchic criminal gangs of Santo Ileso, apart from shinier graphics. If it follows *Saint's Row 4*'s nutty simulation-based silliness, that's OK by us. You're the boss of a four-person gang fighting to take over the city's nine districts, with drop-in/drop-out co-op and with the usual mix of giant professional wrestlers, heavily armed psychopaths, and crazy ladies in hot rods standing in your way. Originally due to be released in February, it has been delayed for a little final polishing.
• Out: August 23 • saintsrow.com



Valheim

With up to ten other players, build fortifications, set up trade routes across the oceans, craft all the weapons and armor you need, and fight the bloodthirsty monsters that lurk in the darkness of *Valheim*'s massive Viking-themed world. Building requires thought and planning, lest your walls come tumbling down.
• Out: Now (early access) • www.valheimgame.com

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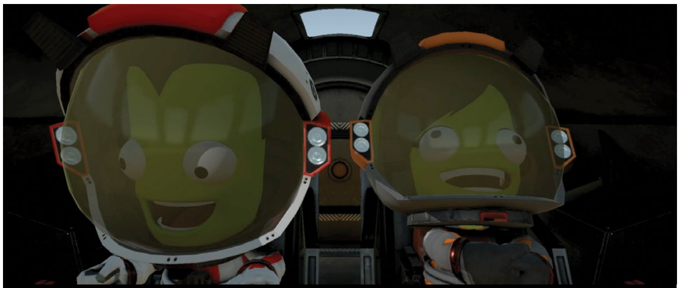
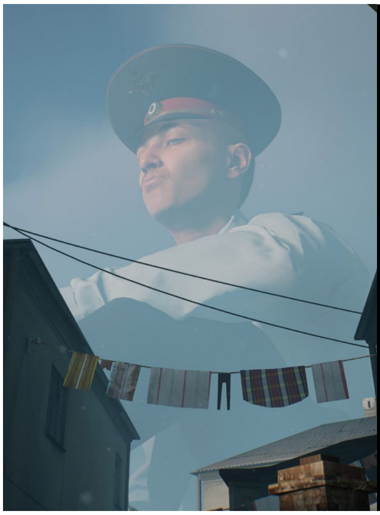


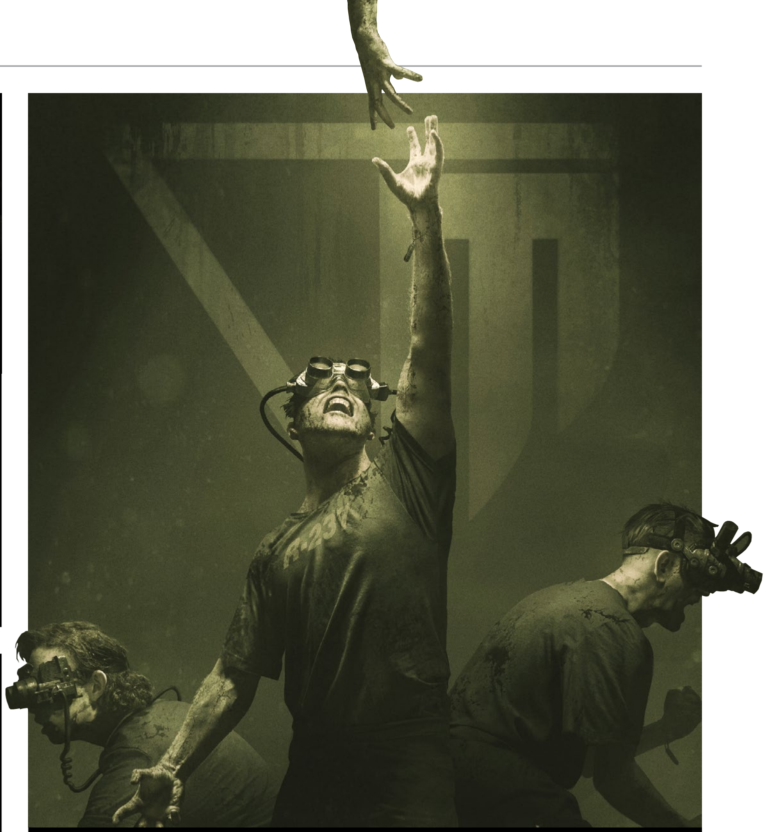
Kerbal Space Program 2

An updated game comes with revised propulsion methods, including Orion (either the current NASA exploration capsule or the bonkers '60s idea of chucking nuclear bombs out of a spaceship) and interstellar travel. There's also a multi-player mode and tutorials to stop the game from being overwhelming.
- Out: TBC • www.kerbalspaceprogram.com



Militsioner

Militsioner sees you held prisoner in a village watched over by a literal giant policeman (it's probably a metaphor), who sees everything. Attempt to escape and his giant hand will lift you up and… who knows? Talking to the cop is part of the game, using your PC's microphone. Let's hope he doesn't talk back.
- Out: TBC
- www.tallboysgames.com

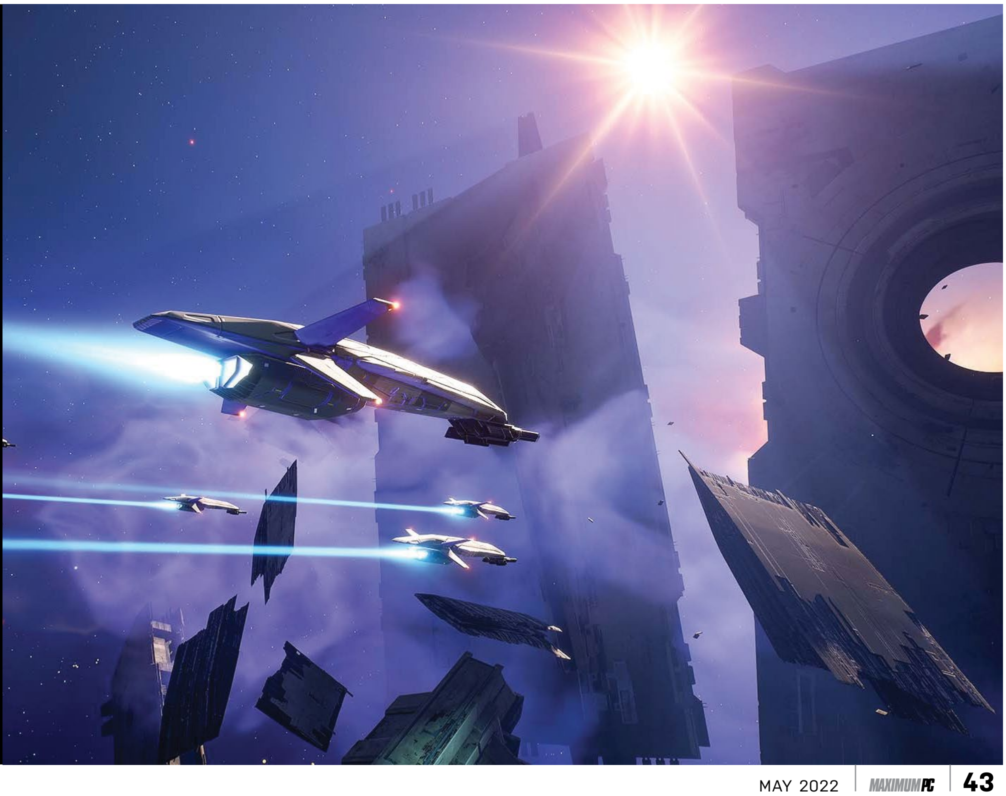


The Outlast Trials

Co-op survival horror, with undertones of brain-washing, mind-control, and murky corporations carrying out dubious experiments on human guinea pigs who have been 'involuntarily recruited'. "It's always better to shit your pants in good company," reads the game description on Steam, so we have a good idea of what we're in for here. The third game in the *Outlast* series of psychological horror games, the team contains former Ubisoft and EA developers based in Montreal.
- Out: TBC • redbarrelsgames.com/games/the-outlast-trials

Homeworld 3

Tactical combat in 3D space has always been *Homeworld*'s USP, and while enormous space-borne derelict spaceships bring a touch of the 3D terrain to *Homeworld*, as you perform trench-runs and dive below cover on their surfaces, there's still plenty of open space on offer. The sense of scale to the game is remarkable, as what appears to be a reasonably large fighter gives way to bigger and bigger ships, only to be blocked out by the shadow of something larger still. A rogue-like co-op multi-player mode sounds especially interesting, structured as a series of randomized enemy waves to be overcome by one or two players, with unlockable weapons that carry over into your next run.
- Out: Q4 2022
- homeworlduniverse.com



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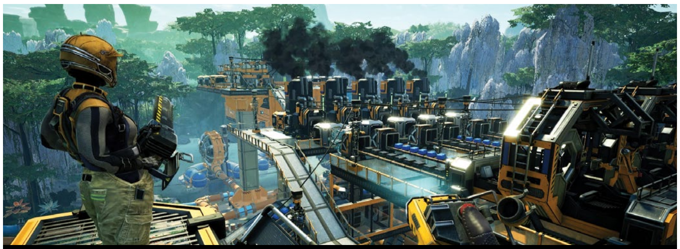
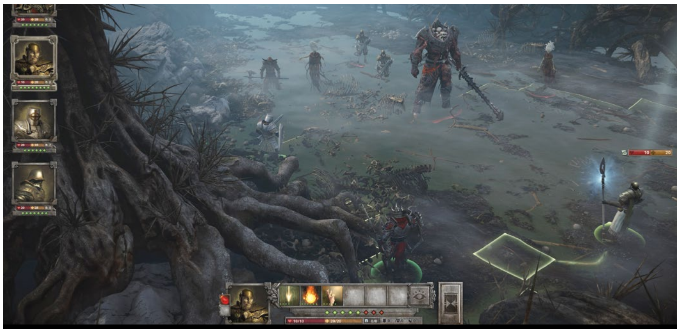


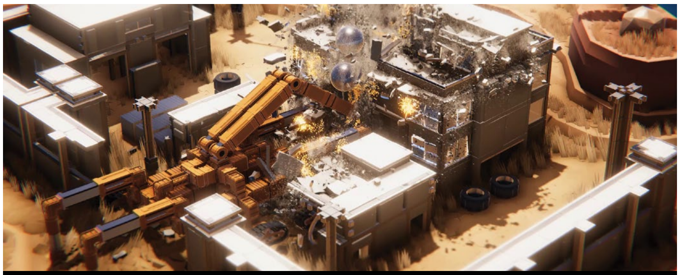
Satisfactory

Satisfactory is a factory building and management game in which you land on an alien planet and set about building a manufacturing plant that sucks up all the natural resources. Construct vast webs of automation, linked by pipes and conveyors, and minimize manual labor whenever you can. There are programmable trains that allow you to streamline the delivery of raw materials or create a massive wreck, depending on your design. The game challenges you to make the most efficient factory you can, or a monstrosity, both are equally valid. • Out: Now (early access) • www.coffeestainstudios.com



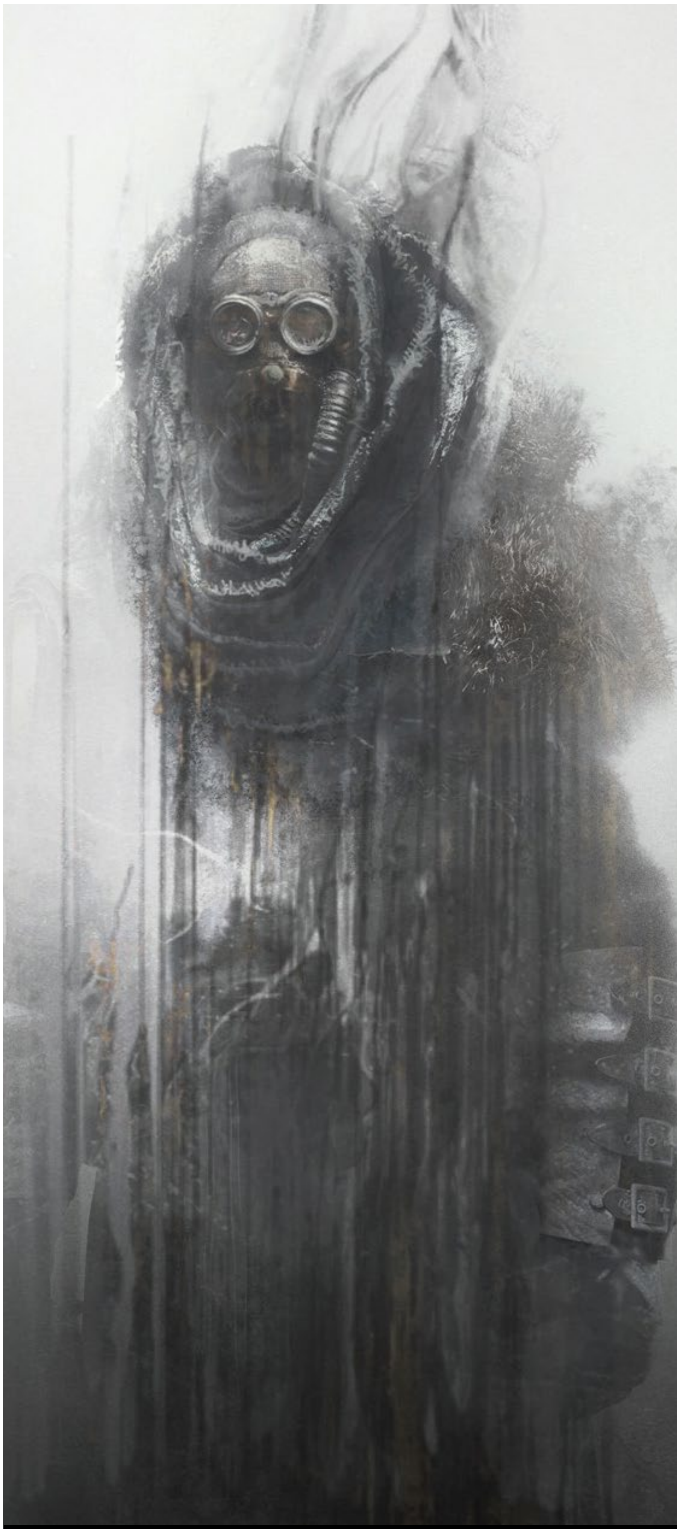
King Arthur: Knight's Tale

In a dark twist on Arthurian legend which sees Arthur dead, you take the role of Sir Mordred, the black knight whose relationship with the old king is complicated. The game takes the form of a turn-based RPG as you recruit a party of knights and others, then take the fight to the monsters and undead that stand in the way of unifying your kingdom and rebuilding Camelot. • Out: April 26 • www.kingarthurknightstale.com



Instruments of Destruction

An immense physics playground in which you build a vehicle then let it rip into buildings and cause as much damage as possible, *Instruments of Destruction* is a whole lot of fun. Presented as an island-hopping adventure where the only goal is to break stuff, each round starts with a construction phase where you customize your vehicle, before setting it loose. Equip it with blades, circular saws, demolition balls, and spikes before ramming it into buildings, some of which hide explosive barrels. • Out: Now (early access) • radiangames.com



Frostpunk 2

The chilly city-management and survival game, which saw you put children to work in the mines, gets a sequel in which oil takes the place of coal as the fuel of choice for keeping the encroaching blizzards of the snowball Earth at bay. As the overseer of an oil-hungry metropolis, you face choices and make sacrifices, soothing conflicts between factions and attempting to shape society in ways you see fit. And sending kids out to drilling rigs, presumably. • Out: TBC • www.frostpunk2.com

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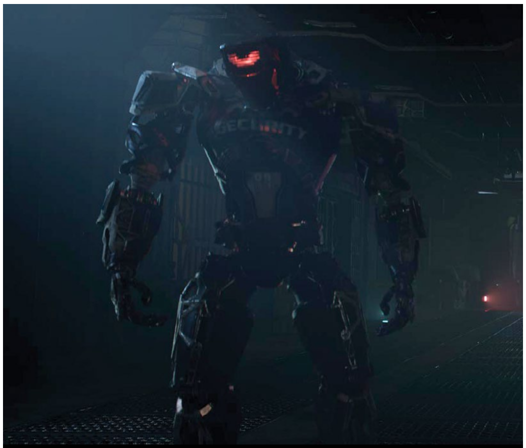
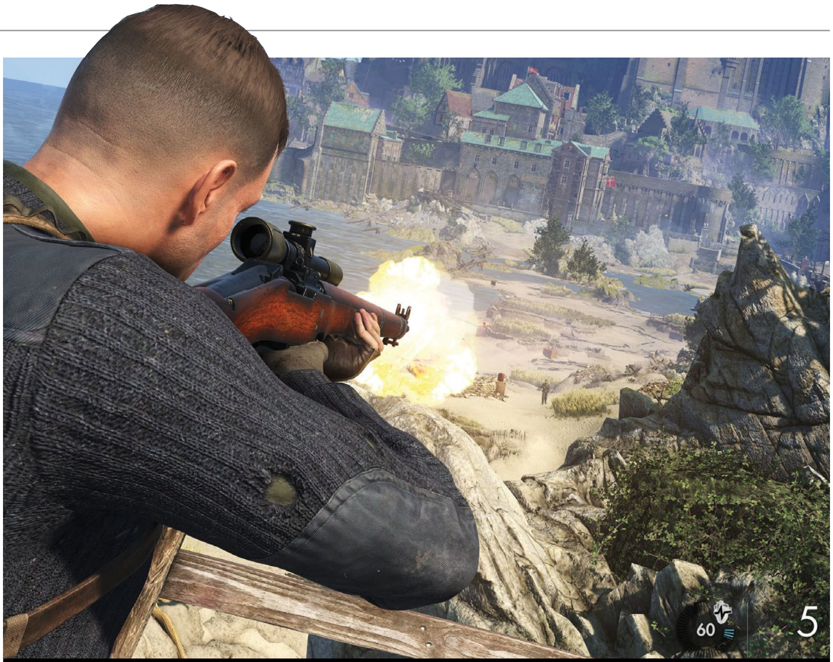


The Callisto Protocol

Set in the Player Unknown's Battlegrounds universe for, we assume, reasons, this horror game veers closer to the likes of *Dead Space*. There's a reason for that, as Striking Distance Studios head Glen Schofield worked at Visceral Games on that series, before going on to co-found Sledgehammer Games and pump out *Call of Duty* titles. There's a hint of *Alien 3* in the game's description, as a corporate-owned prison colony on Jupiter's moon Callisto is caught up in an alien invasion that may or may not have something to do with the prison warden himself.

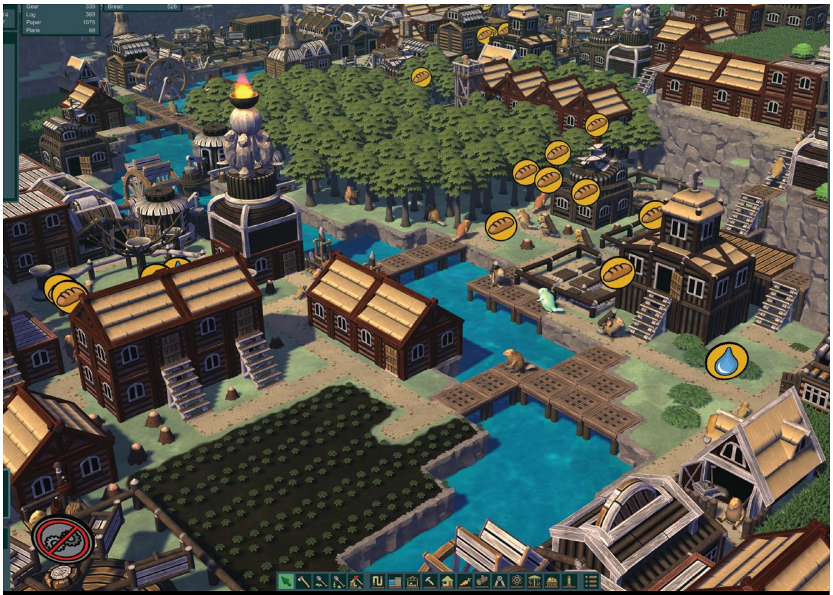
• Out: TBC • www.callistothegame.com



Sniper Elite 5

Enter France in 1944 as part of an elite US Rangers operation, join up with the French resistance, uncover secret Nazi plots and shoot unfortunate Germans in the testicles. Weapons are completely customizable, and the environments have had a photogrammetry-based upgrade that leaves the sun-drenched beaches and pretty French towns you sneak through looking exceptional. The game will be playable in co-op and the trademark X-ray killcam has been enhanced so you can see every bullet rip through enemy flesh. Lovely.

• Out: May 26 • sniperelitegames.com



Timberborn

In early access since September 2021, and expected to spend at least a year there, we stand a chance of seeing a full release of *Timberborn* this year. The twist of this settlement-building game is that humanity has died out and been replaced by beavers, who are busy doing what beavers do best: stockpiling timber and managing water supplies. Two Castoridae factions are playable, each of which beavers away differently to turn the humble plank into sophisticated machinery. While metal can be scavenged from the ruins of human civilization, space is limited, so you'll have to stack buildings vertically to succeed.

• Out: Now (early access) • mechanistry.com

Warhammer 40,000: Chaos Gate - Daemonhunters

It doesn't seem long since *Battlesector*, and we review *Total War: Warhammer III* in this issue, but the Games Workshop games keep coming. We're back in the metal boots of the Space Marines, specifically the Grey Knights chapter, who defend the galaxy against the incursions of chaos. A turn-based tactical RPG, there's a base to upgrade, a squad of customized warriors to build, and a cosmic plague to fend off. Enemies include the Death Guard chapter, who mutate due to an infection ravaging their world.

• Out: May 5 • www.chaosgate.com ⏻

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CENTERFOLD

PERFORMANCE GEAR LAID BARE

Backforce One

WHEN THE FINE FOLKS at Backforce offered us our own *Maximum PC* gaming chair, we jumped at the chance, if only to stop the guys and girls at *PC Gamer* from stealing our seat. The "Max PC" customization is subtle rather than a full-on bespoke affair, but it highlights how Backforce can add this kind of neat personal touch to its chairs. Tell them the words and colors you'd like emblazoned on the velcro shoulder strips, and they'll make it happen for just $13.

There's a lot more to be excited about than lapels on the Backforce One, though, including customizable lighting, folding armrests, and a tailored color scheme that can be matched to your personal tastes or eSports team of choice.

In the flesh (well, polyurethane leather), the chair feels reassuringly well made. We're impressed that it's handmade in Germany but is currently retailing for less than €600 in Europe, which should equate to around $650 when it makes its way to the US.

Backforce has also made some neat packaging and environmental innovations. The cardboard box supports the backrest while you're constructing the chair, so it doesn't move around. And when it has reached its natural end, it can be broken down and recycled, thanks to its wooden back and CFC-free foam construction. Did we mention that it's luxuriously comfortable too? –**GUY COCKER**

---

1 LAPELS

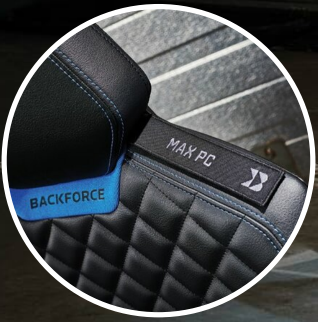
For just $13, you can have a couple of custom patches added to the Backforce to give your livestream presence a more personal touch, or perhaps to intimidate your enemies. We went for the stealth look with our "Max PC" patch, but you can also add color to the border, interior, and the text itself. The stylized 'B' is the Backforce logo.

2 LIGHTING

The Backforce One comes with an LED brooch that adds gamer-friendly lighting to the chair. Gamer Pulse, as Backforce calls it, is a removable puck that offers flashing or solid light effects for up to 20 hours. After that, you can recharge it using a micro-USB cable. It can be customized with any logo, although it won't be visible on livestreams as it's on the rear.

3 FOLD AT HOME

One of the novel features we enjoyed on the Backforce One is the armrests that fold away to the rear, like on an airplane, so they can go completely out of the way when you don't want to use them. There are loads of other features, such as Sync Seat, where the seat automatically adjusts to the back's angle in terms of depth and tilt. Office workers rejoice!



BACKFORCE

SECURE YOUR VPN

Jonni Bidwell casts doubt on the highly profitable VPN business, and explains how you can do better…

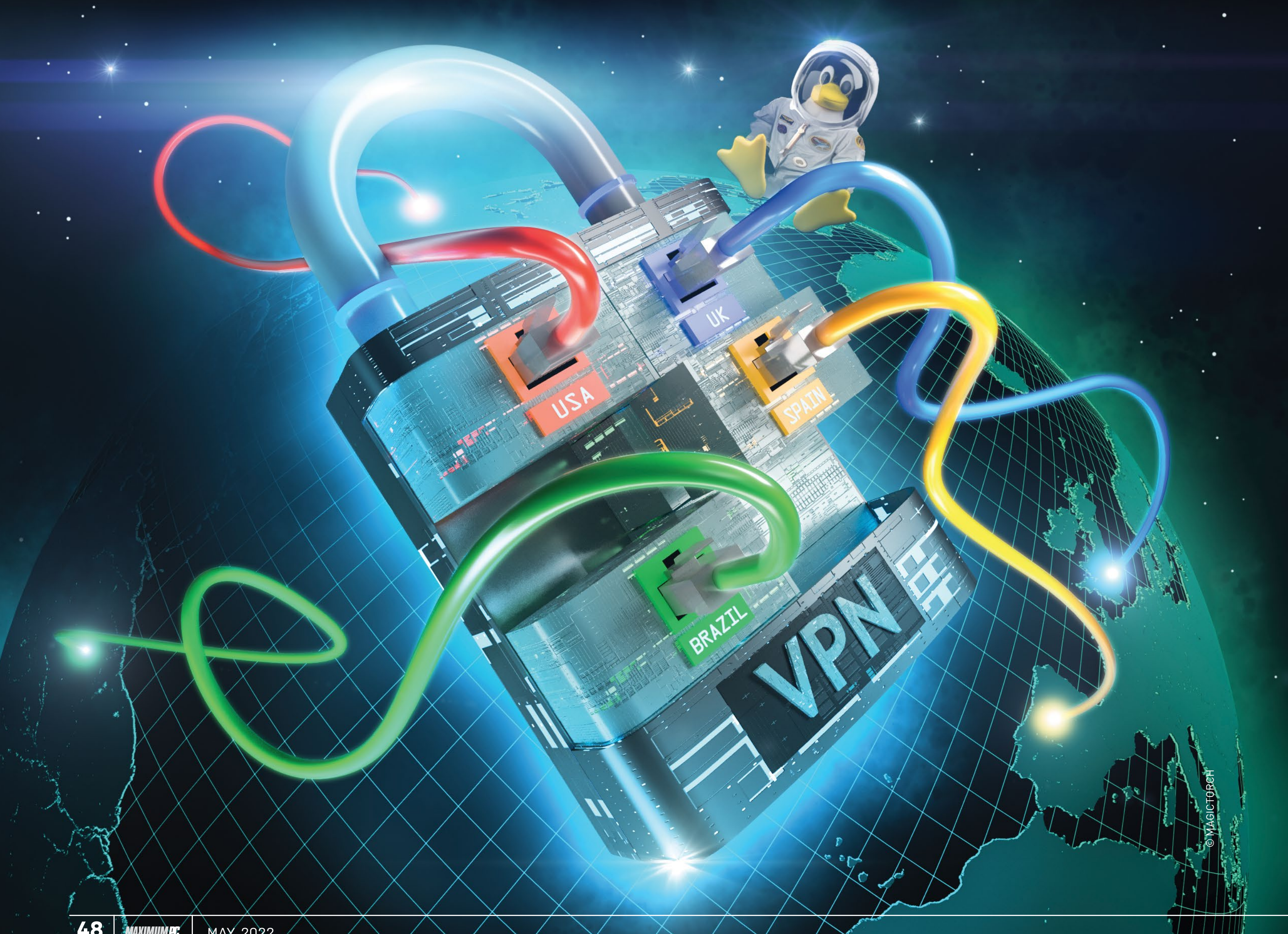
CONSUMER VPNs (virtual private networks) are big business. Indeed, if all the sponsored product placement and affiliate linking is anything to go by, then just a few bucks a month will bring you great security, privacy, and other nebulous benefits, while at the same time making you magically appear as though you're in a country of your choosing.

What they don't tell you is that while you're holidaying, safely, in this faraway IP block, your traffic (albeit partly encrypted) is visible to the VPN provider. It might care more about your monthly subscription payment than what you're using its service for, and it might well implement a 'no-log' policy, but the provider has the same insight into customers' traffic as those customers' ISPs did, up until the point it all vanished into a single VPN connection.

We're not saying all VPNs are bad, just that it's difficult to prove that they're all good. So why not run your own? We'll show you how to use the latest WireGuard technology to route your traffic through your home, or the region of your choosing via a Virtual Private Server. And if you don't trust your ISP or VPS provider, we'll look at Tor—the gold standard for privacy.

If your goal is to check out prices in different currencies or to mitigate the risks of public Wi-Fi, then a VPN will help you do that. If your goal is to access geo-blocked content (different Netflix regions or Steam prices, say), then a VPN might help you do that too, but it almost certainly goes against the provider's Terms of Service. Believing a VPN will anonymize your browsing, protect you from tracking cookies, malware and the plague, however, is wide of the mark.

Your IP address is far from the only means companies have of identifying you. We'll see that browser fingerprinting, DNS interception and even good old-fashioned spam can undermine any protections a VPN might offer.



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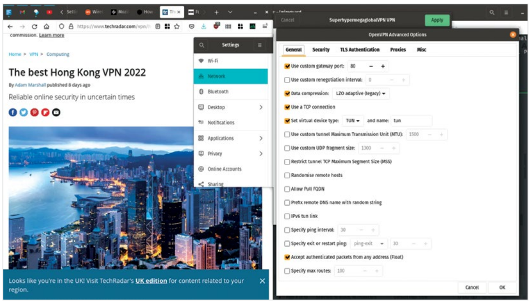
The why and wherefore of VPNs

It's not VPNs that are bad, rather people's unrealistic expectations of privacy. And, in a pay-per-click age, honesty

SEARCH ONLINE FOR "why I need a VPN" and you'll find flashy websites framing all sorts of shoddy prose on the perils of "unprotected" browsing. Such diatribes should be taken with a pinch of salt. Yes, there are companies that sell your data. Yes, there are brutal regimes that punish anyone caught browsing websites that go against their ideologies. Yes, Google is mostly blocked in China. And yes, a VPN might help you with this. But it's perhaps not as essential as people think.

Anyway, we're getting ahead of ourselves. A VPN is an encrypted tunnel between two, generally distant, machines. There are a variety of protocols by which one can achieve this, but they all enable the client machine to access resources (web pages, VOIP services, internal company resources) using the server as a proxy. Furthermore, established public key cryptography and key exchange protocols are leveraged so that anyone eavesdropping on the VPN connection has an extremely small chance of being able to make sense of the data. And anyone looking at the connection from the VPN server to the outside world (if it's used that way) won't be able to see the client's IP address.

That all sounds quite good—and it is, as long as you trust your VPN provider. Ascertaining that trust, however, is hard. In 2016, a free VPN service called Hola breached user trust. It provided a browser plugin that enabled users to switch regions. However, those users were unwittingly becoming rather more involved in the VPN than they would have liked. Hola's business model at the time was to tunnel traffic between users so that their machines became proxies. This potentially made users vulnerable to all kinds of lawsuits and investigations, since traffic is no longer encrypted after it has left the VPN tunnel. Most of the web is protected by HTTPS now, but that still reveals domain names and IP addresses.



The best Hong Kong VPN 2022

By Adam Marshall published 8 days ago

Reliable online security in uncertain times

Looks like you're in the UK! Visit TechRadar's **UK edition** for content related to your region.

- ☑ Use custom gateway port: 80
- ☐ Use custom renegotiation interval: 0
- ☑ Data compression: LZO adaptive (legacy)
- ☑ Use a TCP connection
- ☑ Set virtual device type: TUN and name: tun
- ☐ Use custom tunnel Maximum Transmission Unit (MTU): 1500
- ☐ Use custom UDP fragment size: 1300
- ☐ Restrict tunnel TCP Maximum Segment Size (MSS)
- ☐ Randomise remote hosts
- ☐ Allow Pull FQDN
- ☐ Prefix remote DNS name with random string
- ☐ IPv6 tun link
- ☐ Specify ping interval: 30
- ☐ Specify exit or restart ping: ping-exit 30
- ☑ Accept authenticated packets from any address (Float)
- ☐ Specify max routes: 100

Network Manager supports all kinds of VPN connections, but there are plenty of questionable operations out there.

We'd hope that such behavior is a thing of the past, and for the most part, it is. But that doesn't mean we can trust what these fly-by-night VPNs are telling us. Many of them boast of a 'no logging' policy, for example, yet in 2020, seven such services based in Hong Kong accidentally leaked some 1.2TB of user logs. These included cleartext passwords, session keys, domains visited, browser user agent strings, and IP addresses. NordVPN, for a long time considered more reputable than other services, experienced a data breach in 2018, although no customer data was taken.

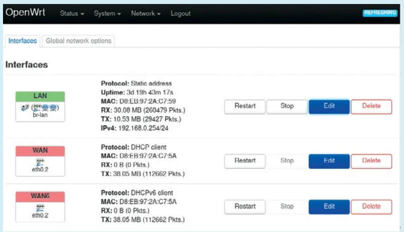
These may have been isolated incidents, but would you trust such operations to aggregate all your internet traffic? Or, put it another way, do you distrust your ISP enough that giving that information to an unknown entity seems like a good idea?

ENTERPRISE AND PERSONAL VPNs

As we were writing this feature, a company-wide email appeared with a familiar beginning: "The IT department is investigating an outage". This time it was the corporate VPN that was out and, since most staff were working from home, they were unable to access corporate services. For us, that meant no fonts, no Creative Cloud license validations, and we couldn't even log into the IT Helpdesk to make them aware of our disgruntlement.

But what we should say is that corporate VPNs are (when they work) a good thing. This, despite using some of the same technologies (for example, OpenVPN) they are used for entirely opposite purposes to the shady VPNs we're on about. Businesses use their VPNs to restrict access to resources and use hardware appliances to achieve this.

Consumer VPNs are more about circumventing restrictions and are run using cheap, commodity virtual private servers (VPSes). It might be easier to rent a VPS from Amazon or Digital Ocean or the like in an EU or US data center, but it's still possible to find boxes in countries where the laws are more relaxed with respect to what can and can't be done with your internet connection. And that's the attraction for many people.



LAN — **Protocol:** Static address, **Uptime:** 3d 19h 43m 17s, **MAC:** D8:EB:97:2A:C7:59, **RX:** 30.08 MB (260479 Pkts.), **TX:** 10.53 MB (29427 Pkts.), **IPv4:** 192.168.0.254/24

WAN — **Protocol:** DHCP client, **MAC:** D8:EB:97:2A:C7:5A, **RX:** 0 B (0 Pkts.), **TX:** 38.05 MB (112662 Pkts.)

WAN6 — **Protocol:** DHCPv6 client, **MAC:** D8:EB:97:2A:C7:5A, **RX:** 0 B (0 Pkts.), **TX:** 38.05 MB (112662 Pkts.)

OpenWRT and other open-source router firmware allow you to run a VPN from home.

Run a WireGuard VPN

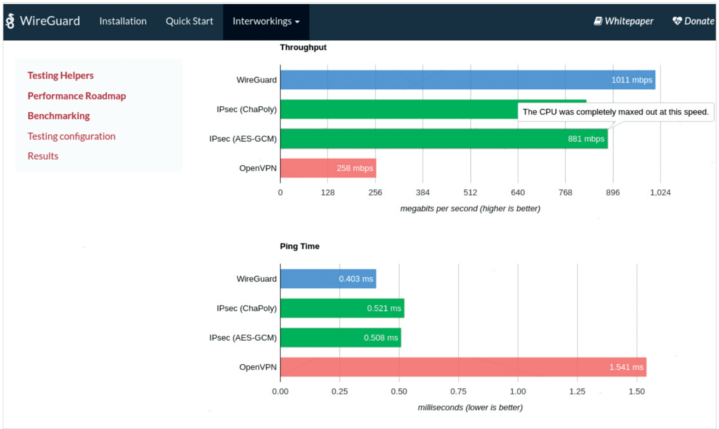
WireGuard is the newest, leanest, meanest VPN protocol on the scene. Let's get those wires guarded!

THANKS TO THE WONDERS of open source, it is possible to run your own VPN. Depending on your purposes (i.e. if you want to break rules), this might not be for you. But if you want a secure tunnel to your home connection or a VPS (virtual private server) when you're away, then we'll show you how.

Before that though, let's look at a lesser-known feature of another jewel of FLOSS, OpenSSH. As it happens it's full of hidden gems. For example, during an SSH session, if you type Enter then ~ then C, you can access a super-secret command shell, from which you can add any port forwarding options. Very handy if you forgot to add them when you initiated the session.

See the box (below) for how to set up a rough 'n' ready not-quite VPN with SSH. Setting up a grown-up VPN is a little harder but, hopefully, we can fit it in the remaining space. WireGuard is still quite new (it was only made widely available in April 2020) and while it aims to be simpler than OpenVPN and others—and architecturally, it is—there's still a lot of manual setup involved.

In the future, there will be additional helpers for dealing with key distribution and IP address allocation, but for now, we'll have to do everything ourselves.



WireGuard far outperforms its peers, according to fetching graphs on its website. It's also simple enough that we can set it up in two pages.

WireGuard by design wants to have a minimal attack surface, and as such, it is firmly a network layer service. Things like DHCP (or anything analogous to it that might help WireGuard) exist elsewhere in the OSI stack, so they will never be added to WireGuard itself.

LAY THE GROUNDWORK

The first thing we need to do is install the appropriate utilities on both machines. First, install the userspace part with:

```
$ sudo apt install wireguard-tools
```

This will create the directory /etc/wireguard into which we'll dump a keypair:

```
$ wg genkey | sudo tee /etc/wireguard/privkey
$ sudo cat /etc/wireguard/privkey | wg pubkey |
sudo tee /etc/wireguard/pubkey
```

Since WireGuard's configuration directory is owned by root, we need to use this rather messy `sudo` and `tee` incantation. Keypairs need to be generated on both machines too. WireGuard needs to know the IP addresses and public keys of any peer that connects to it. If you're at home on your local network connecting to another local machine (a fairly pathological use case, but good for testing things), then use the LAN IP addresses. If you're dealing with a machine or VPS that's not on your LAN, you'll need to use your external IP (which you can get by entering `ip` into DuckDuckGo). WireGuard will create a new interface on both machines, each with their own IP addresses.

It's a bad idea to use anything other than the reserved private IPv4 ranges (for example, 192.168.*) for this, and it's an equally bad idea to use ones that conflict with your LAN. We've used the 10.* prefix (another private range), but if this is used on your LAN you should use something else.

We need to prepare WireGuard configurations at both ends, but don't worry—it looks worse than it is. On the remote, server machine edit (with sudo) /etc/wireguard/wg0.conf and populate it as follows. You'll want to copy and paste the appropriate keys.

BROWSING BY PROXY

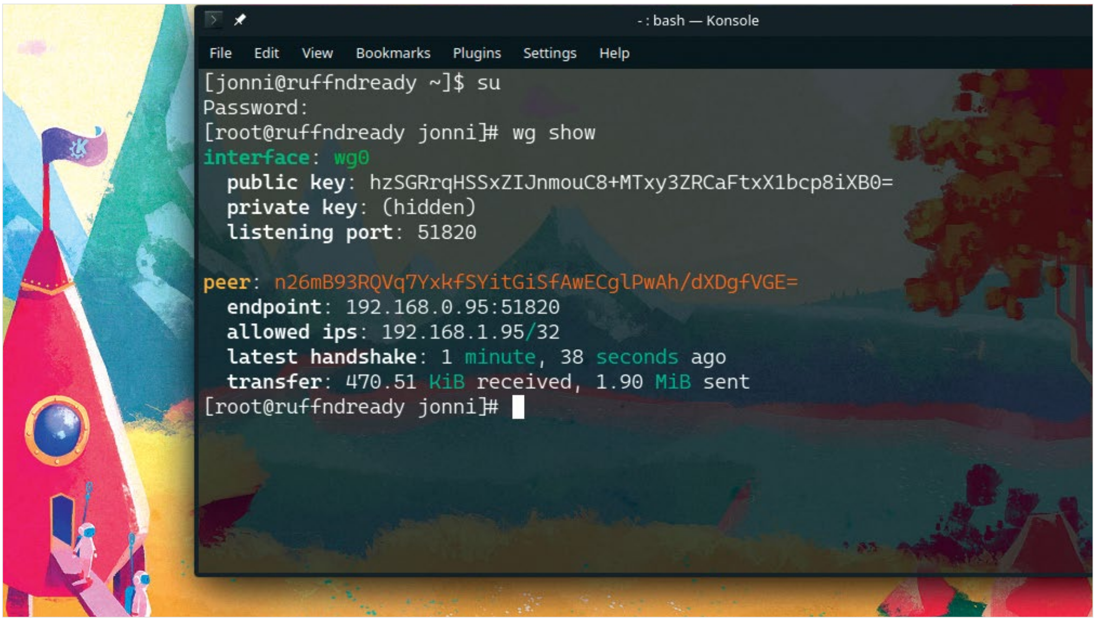
Another of OpenSSH's joyous treasures is that it can be used as a SOCKS proxy. This isn't the same as a VPN; it works at the session level rather than the transport level. But it does enable traffic to be tunneled over an encrypted connection and it does obfuscate the client IP address, which is certainly part of what a VPN does.

If you have a remote machine that you're already in the habit of SSHing into, then to achieve this SOCKS magic, instead of your usual incantation, add the following:

```
$ ssh user@myserver.com -D 3128
```

This will send traffic from port 3128 on the local machine to the proxy (you can use any available port number). Also, the `-D` option can be activated from the internal shell we mentioned earlier. Many applications support SOCKS proxies, but they need to be individually configured. To use your rough and ready proxy with Firefox, go to Settings → General → Network Settings and select Manual Proxy configuration. In the SOCKS Host box, enter `localhost` and enter `3128` in the Port box. Leave the radio button at the SOCKS v5 setting.

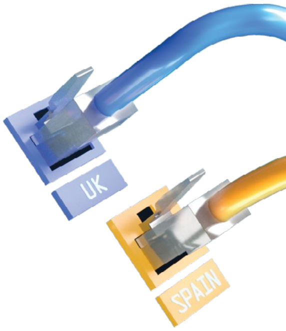
Hit OK and all your web traffic will be routed via your SSH server. Don't forget to reset the network settings when you disconnect the SSH connection, otherwise, the web will be replaced with a "proxy is refusing connections" error.



```
[jonni@ruffndready ~]$ su
Password:
[root@ruffndready jonni]# wg show
interface: wg0
  public key: hzSGRrqHSSxZIJnmouC8+MTxy3ZRCaFtxX1bcp8iXB0=
  private key: (hidden)
  listening port: 51820

peer: n26mB93RQVq7YxkfSYitGiSfAwECglPwAh/dXDgfVGE=
  endpoint: 192.168.0.95:51820
  allowed ips: 192.168.1.95/32
  latest handshake: 1 minute, 38 seconds ago
  transfer: 470.51 KiB received, 1.90 MiB sent
[root@ruffndready jonni]# 
```

Here we can see a peer connected successfully. Adding more peers becomes exponentially more complex, though.



The `[Interface]` section describes the local instance of WireGuard, so use its (not yet enabled) IP and the private key generated on it here. The `[Peer]` section describes anyone connecting to it, so use the public key from the local machine here. Using a `/32` mask in the IP address means only this peer is allowed to connect.

```
[Interface]
Address = 10.0.0.2/24
PrivateKey = ...=
ListenPort = 51820

[Peer]
PublicKey = ...=
AllowedIPs = 10.0.0.3/32
```

Do the same thing on the local machine, using a different 10.0 address and in the `[Interface]` section. In the `[Peer]` section you use the public key from the server. Replace the `AllowedIPs` setting to forward all traffic. And also add an endpoint so WireGuard knows to connect to your server's actual IP.

We've also added a keepalive setting, which the documentation says will help maintain NAT connections:

```
AllowedIPs = 0.0.0.0/0

Endpoint = 192.168.x.y:51820
PersistentKeepalive = 30
```

Almost there... you'll need to set

```
$ sudo sysctl net.ipv4.ip_forward=1
```

on both sides in order for traffic to be forwarded. Now start WireGuard on the server with

```
$ sudo systemctl start wg-quick@wg0
```

A side-effect of WireGuard is that it's easy for a misconfiguration to render the remote machine inaccessible if you use a conflicting IP in the `[Interface]` section. But most VPSes enable you to reboot, so it's not the end of the world if that happens. You can check everything's working on either machine by running

```
$ sudo systemctl status wg-quick@wg0
```

If there are no errors (including those perpetrated by yourself) you should be able to access the server using its imaginary 10.* IP address as well as its real one. However, you've probably noticed your local machine has lost its connection to the outside world. That's easy to fix with some firewall rules. We're assuming a new style interface name `enp1s0`, the command `ip a` will show you the correct name to use here. If you're running Ufw (on the server) you might need

```
$ sudo route allow in on wg0 out on enp1s0
```

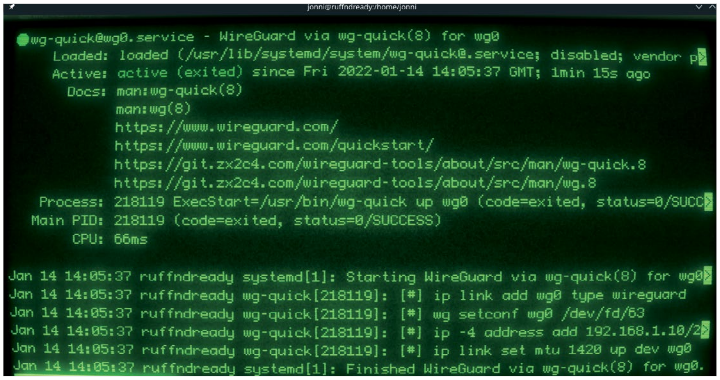
to enable WireGuard traffic to ingress the network. You'll also need

```
$ sudo iptables -t nat -I POSTROUTING -o enp1s0 -j
MASQUERADE
```

so that traffic is NAT-ed accordingly. These commands (as well as the appropriate commands to deactivate things) can be added to the configuration file so that they are automated in the future. See the documentation for how to do this.

We've demonstrated a fairly minimal example of WireGuard usage, but it's capable of much more. It supports IPv6, so if both machines have IPv6 connectivity then it's easy to use that as well or instead. It's also possible to add another layer of security in the form of a pre-shared key. As the name suggests this is shared between client and server. It can be generated with `wg genpsk` and then copied and pasted at both ends with a `PresharedKey =` directive.

Success! Our WireGuard configuration worked and it's made more exciting by Cool Retro Terminal.



```
●wg-quick@wg0.service - WireGuard via wg-quick(8) for wg0
     Loaded: loaded (/usr/lib/systemd/system/wg-quick@.service; disabled; vendor p>
     Active: active (exited) since Fri 2022-01-14 14:05:37 GMT; 1min 15s ago
       Docs: man:wg-quick(8)
             man:wg(8)
             https://www.wireguard.com/
             https://www.wireguard.com/quickstart/
             https://git.zx2c4.com/wireguard-tools/about/src/man/wg-quick.8
             https://git.zx2c4.com/wireguard-tools/about/src/man/wg.8
    Process: 218119 ExecStart=/usr/bin/wg-quick up wg0 (code=exited, status=0/SUCC>
   Main PID: 218119 (code=exited, status=0/SUCCESS)
        CPU: 66ms

Jan 14 14:05:37 ruffndready systemd[1]: Starting WireGuard via wg-quick(8) for wg0>
Jan 14 14:05:37 ruffndready wg-quick[218119]: [#] ip link add wg0 type wireguard
Jan 14 14:05:37 ruffndready wg-quick[218119]: [#] wg setconf wg0 /dev/fd/63
Jan 14 14:05:37 ruffndready wg-quick[218119]: [#] ip -4 address add 192.168.1.10/2>
Jan 14 14:05:37 ruffndready wg-quick[218119]: [#] ip link set mtu 1420 up dev wg0
Jan 14 14:05:37 ruffndready systemd[1]: Finished WireGuard via wg-quick(8) for wg0.
```

© WIREGUARD

Tor and other VPN alternatives

Tor has long been regarded as the gold standard for privacy and anonymity. Let's see how easy it is to go dark

VPNS ARE ADVERTISED as being a boost for privacy, security, and anonymity. Those nouns may well apply in particular situations. But it's hard to call a VPN an anonymous service when you have to sign up with a very un-anonymous credit card. And it's hard to say for sure if they're private or secure if you're talking about a bunch of effectively centralized servers that no one can audit. Fortunately, there are alternatives, including one you've probably already heard of, Tor (formerly known as The Onion Router).

Similar to a VPN, Tor proxies traffic through encrypted tunnels, obfuscating users' IP addresses. It's different, though, because no one entity owns Tor. Anyone can run a Tor node and anyone can connect to it for free, without any sign-up process. Tor connections—or 'circuits'—are routed over at least three Tor nodes, with each hop unwrapping a layer of encryption (hence the old Onion name) to discover the next.

In this way, there's no correlation between the first and final nodes. Tor can be used in one of two ways: either as an intermediary to regular web service or to access Tor's hidden services, which have their own .onion domain names.

ALL MANNER OF TOR USERS

You might have heard of Tor being used for organized crime, assassinations for hire, or any number of other bad things. Malfeasance certainly takes place there, but there are a number of legitimate services operating on the onions, too. The BBC News website, for example, is blocked in countries that would rather its citizens only tune in to state media. So, since 2019 the BBC has operated a Tor service at www.bbcnewsv2vjtpsuy.onion. Not exactly easy to remember, but a small price to pay to access a free press.

Tor service names are generally 16-character long random strings, but with a little effort, it's possible to personalize the first few letters of a string. Facebook (also blocked in a number of countries, but not necessarily deserving of a mention in a privacy feature) operates a Tor service at https://facebookcorewwwi.onion, for example.

It's worth mentioning that logging into Facebook and Google-type services does tend to identify you to some extent. Those ad-tracking cookies and Like and Share buttons follow you around whether you're using a VPN, Tor, or both. More on how to evade them over on the following page. For now, just make sure you're logged out of these services if you're doing anything other than using them on Tor. Again, we've got ahead of ourselves and haven't told you how to use Tor. Let's remedy that by visiting www.torproject.org/download and downloading the Tor Browser Bundle.

Extract it to your home folder (or wherever you like) and then run the bundled desktop file to add it to your Applications menu:

```
$ cd ~/tor-browser_en-US/
$ ./start-tor-browser.desktop --register-app
```

If you don't like having a static copy of the Tor browser in your home directory, then you can add the Debian repository.

How to do that is explained at https://support.torproject.org/apt/tor-deb-repo.

OTHER WAYS TO VPN

The other popular way to roll your own open-source VPN is with the OpenVPN protocol. This is a much more complicated beast than WireGuard, but it's still easy enough to get started with a simple setup. This all relies on you having access to a remote server (if you want to use a VPN in the conventional way), and on you being confident that said server won't be compromised. Because if it was there's not much point in running a VPN on it.

We're not going to recommend any commercial service over any other, but we'd consider Mozilla a force for good in a world full of Metas and Alphabets and Yahoo! And it so happens you can support them by subscribing to their VPN service. It uses WireGuard (without you having to plan your subnets) and works with Linux. It might be a little pricier than other offerings but, hopefully, we've cast enough doubt on such offerings already. And no, Moz didn't pay us to write this.

Mozilla VPN

Mozilla VPN for Ubuntu Linux — a perfectly private pairing

As a fan of Ubuntu Linux, you already know the importance of privacy and security online. You probably also know about Mozilla and what we stand for — a private, open and free internet for all. It's time to bring the two together.

Mozilla needs to eat too, and it does care about its users. Perhaps this makes the company more deserving of your patronage.

©MOZILLA

If you look on FlatHub (or if your application manager plugs into that) you can also avail yourself of the Tor Browser Launcher. This automates the process of downloading, configuring, and keeping the browser up to date.

That browser, as you'll see when you launch it, is a customized version of the Firefox ESR release. Hit the Connect button and see if you're able to connect to Tor. It will take a few seconds to establish relays and circuits and such, but even if you're behind a firewall, it should still find a way. In some countries, publicly listed Tor relays are blocked, but there are options to remedy this. On the Tor Settings page, you can opt to use a bridge, which may come from a Tor Project listing or a trusted source. It's harder to block Tor bridges since a complete list of all of them doesn't and can't exist.

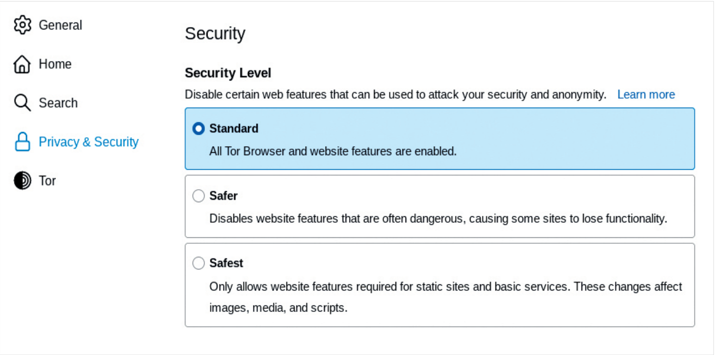
Once connected, try and view your favorite website and you'll see one of the main drawbacks of Tor. It's slow. Sometimes very slow. All bandwidth on Tor has effectively been donated, so it's considered bad form to (try to) use it for data-heavy activities such as streaming video. And if you use YouTube, since you have to sign in to watch videos, all you're really doing is telling Google that you're using Tor. And that will inform future adverts it chooses to sling your way.

Another odious technique the bad VPN sites use is to try to claim they're better than Tor because Tor is slow. Unfortunately, lots of VPNs, especially bad ones, have some sort of bandwidth limits, too.

EXIT, STAGE LEFT

The bad VPNs vs Tor debate covers other areas too. It has been well-publicized that occasionally people operate malicious exit nodes. These are the last hop before traffic leaves the Tor network and is routed to the requested resource. If the user is accessing a Tor Service, i.e. a .onion address, then exit nodes are not used. Otherwise, they can see which domains are being accessed. Rather like a VPN provider can (in theory, if they accidentally left their no-logging option perhaps). Unlike the VPN case though, the exit node has no knowledge of the user's IP address. So again this argument is spurious. It's probably more accurate to say that bad Tor exits are better than bad VPNs. Although neither is that good, really.

If you want to find other Tor sites, a good starting point is The Hidden Wiki. This is a regular website (you can access it without Tor) full of links to popular Tor sites. We would tell you the address, but since some of those sites aren't exactly for family viewing, we'll leave it for your favorite search engine. By default, the Tor Browser uses Permanent Private Browsing mode, which will delete all cookies and site data when the browser is closed. Like Firefox's regular Private windows, it also isolates different website cookies from one another, making it harder (if not outright impossible) for ad trackers to do their respective things.



Security

Security Level

Disable certain web features that can be used to attack your security and anonymity. Learn more

● **Standard**
All Tor Browser and website features are enabled.

○ **Safer**
Disables website features that are often dangerous, causing some sites to lose functionality.

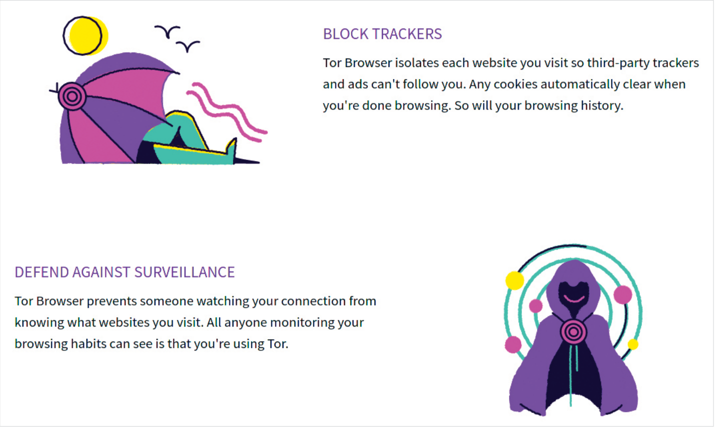
○ **Safest**
Only allows website features required for static sites and basic services. These changes affect images, media, and scripts.

The Tor Browser includes NoScript and HTTPS Everywhere, and comes with three security settings depending on your levels of paranoia.

Much is made of the fact that Tor was originally a Naval Research Project, and for a long time was funded by the US Department of State. There is still some government funding for Tor, but most contributions come from the private sector. A famous NSA presentation entitled 'Tor Stinks' was leaked by Edward Snowden in 2013. In it, our favorite three-letter intelligence agency decried their inability to decrypt Tor traffic but noted that targeted de-anonymization was theoretically possible with some effort. So there's no secret Tor back door, but all kinds of attacks have been both theorized and attempted.

In 2014, researchers at Carnegie Mellon University carried out a successful de-anonymization attack against Tor. Two years later it was confirmed that the USG had paid Carnegie SEI institute a considerable sum to research this. And that the aim of the exercise was to catch the operator of a darknet marketplace, which they duly did.

So Tor isn't impenetrable, and new and inventive ways will be found to attack it. But it's an open-source project and, as such, findings will be shared and, we'd hope, vulnerabilities fixed. There are malicious nodes operating (see https://bit.ly/lxf286-kax17-vs-tor-users), but also lots of smart people tracking them. Your VPN company might do the same, but as @SwiftOnSecurity once said, "I don't use a VPN because I'd rather Comcast aggregate my data than some dude wearing a dolphin onesie in his basement in Zurich."



BLOCK TRACKERS

Tor Browser isolates each website you visit so third-party trackers and ads can't follow you. Any cookies automatically clear when you're done browsing. So will your browsing history.

DEFEND AGAINST SURVEILLANCE

Tor Browser prevents someone watching your connection from knowing what websites you visit. All anyone monitoring your browsing habits can see is that you're using Tor.

Tor aims to protect you from all kinds of threats, but sufficiently determined adversaries and advertisers will always find a way.

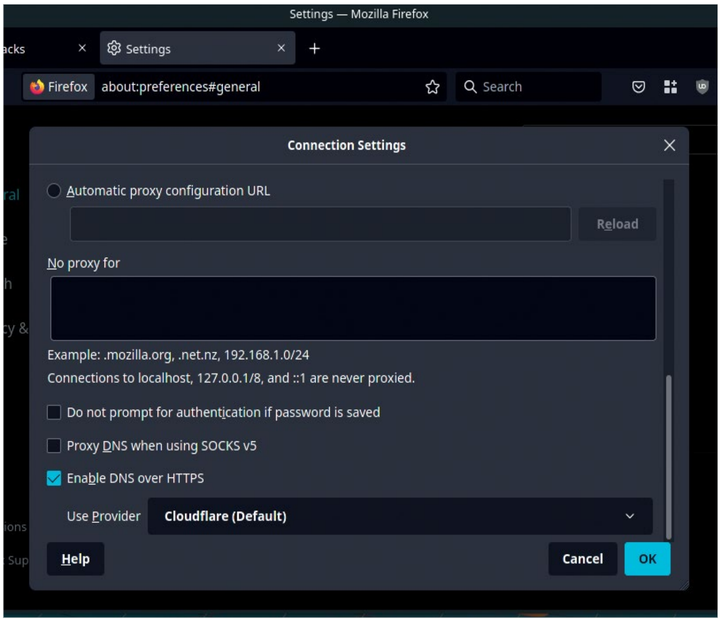
Extra measures

See what VPNs don't and can't protect against, and bolster your privacy with a layered approach

WHEN YOU CONNECT to a VPN, as well as proxying your traffic and setting the corresponding updates to your routing table, it may also provide you with different DNS settings. On paper, this was a reasonable idea. Traditional DNS requests (for example, where a website is resolved to 172.31.5.172) are transmitted in the clear, so even if the operator of a DNS server (typically one's ISP) doesn't know the web page a client is looking at, they at least are aware of the server it's on. This is known as DNS leakage. You may use another DNS server (such as Cloudflare's easy-to-remember 1.1.1.1 public offering), but again this is only viable if you trust that operator more than your ISP.

ISPs may also block certain domains at the DNS level, so for a time using someone else's DNS server was seen as a free and easy way around this by nefarious pirates, whose activities we do not condone. Many ISPs are aware of this, and many have taken the rather heavy-handed measure of performing DNS interception. Remember, we said DNS went over in the clear? Well, that makes it woefully easy for your ISP to just reroute those port 53 requests back to their DNS.

So VPNs now market themselves as providing DNS-leak resistant technology. Indeed, some offer an even more budget-friendly "DNS-only" option. The mechanics of this are straightforward: just tunnel DNS requests as well as (or instead of) other traffic. Again, this is just moving the problem of trusting the ISP upstream, to trusting the VPN operator.



Connection Settings

○ Automatic proxy configuration URL

No proxy for

Example: .mozilla.org, .net.nz, 192.168.1.0/24

Connections to localhost, 127.0.0.1/8, and ::1 are never proxied.

☐ Do not prompt for authentication if password is saved

☐ Proxy DNS when using SOCKS v5

☑ Enable DNS over HTTPS

Use Provider: Cloudflare (Default)

You will find the option to enable DNS over HTTPS hidden away in Firefox's network settings.

While we may have no real problem with our government blocking torrent and streaming sites, or with ISPs voluntarily blocking child pornography sites, the same techniques are used by the brutal and anti-democratic regimes of the world to repress dissidents, activists and journalists. And that we cannot condone. One technical approach is to switch from classical DNS to DNS-over-HTTPS (DoH).

As the name suggests, this uses the same layer as secure web browsing to conduit DNS requests. Firefox already does this by default in the US for web browsing, but you can also set it up system-wide. That way, DNS requests are not only hidden amongst regular web traffic, they're also immune to interception (if you have faith in HTTPS, which you probably should).

Back in 2019, a largely insignificant organization representing large ISPs had nominated Mozilla for an "Internet villain of the year" award based on its plans to roll out DoH by default. Allegedly because it aided and abetted piracy. In response, Firefox announced it would not be trialing DoH-by-default in some places, such as the UK. Indeed, it's still (as far as we could fathom) only the default in the US, but that hasn't stopped thousands of Firefox users turning the option on for themselves. Perhaps uptake has been aided by the friendly prompt that offers to "enable secure browsing" on first usage.

The DoH approach is no silver bullet though. There need to be entities operating DoH-enabled servers, and users need to be able to trust those entities. There are other efforts to secure DNS, most notably DNSSEC that ensures requests and responses aren't tampered with in transit. But that's complicated. What's unfortunately not complicated is running a rogue Wi-Fi hotspot in a coffee shop. From there you (well, hopefully not you, but someone bad) could return poisoned DNS responses to redirect users to cloned, password-harvesting versions of popular sites.

Or they might perform SSL-stripping attacks to try and get around encrypted web browsing (HTTPS), or they might even trick the user into installing a rogue Certificate Authority in their browser. That would be bad, and this is exactly the case where you might prefer to use a VPN. Though ideally one that you're running yourself.

PRIVACY AND AUTHENTICITY

We mentioned HTTPS earlier, which thanks to the efforts of Let's Encrypt has become ubiquitous across the web. This provides not only privacy so that no one observing the connection between you and the webserver can see beyond the first slash in the URL. But also authenticity, so you know, for example, the website you visit is indeed the same server as it was when the certificate was issued.

Some VPN providers twist the facts a little here.

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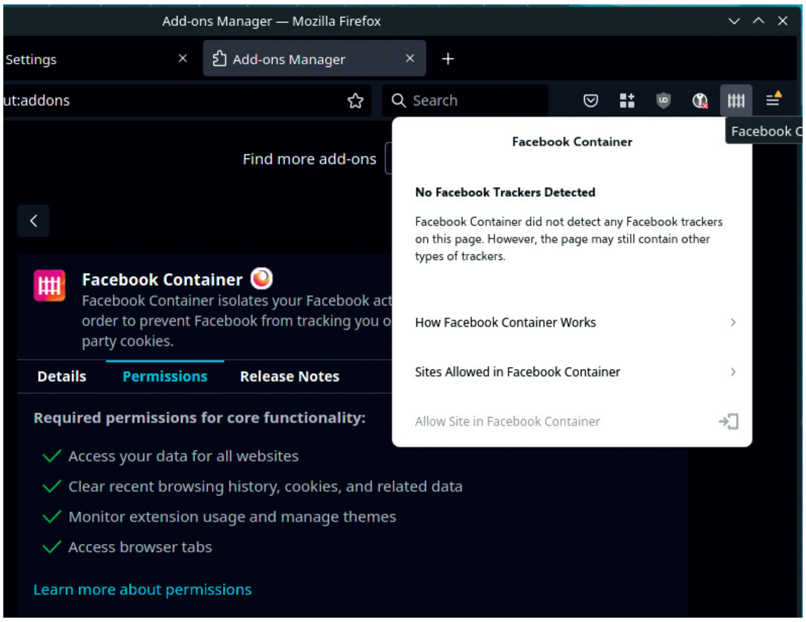


Add-ons Manager — Mozilla Firefox

Settings

Add-ons Manager

ut:addons

Search

Facebook C

Find more add-ons

Facebook Container

Facebook Container isolates your Facebook act
order to prevent Facebook from tracking you o
party cookies.

Details | Permissions | Release Notes

Required permissions for core functionality:

✓ Access your data for all websites
✓ Clear recent browsing history, cookies, and related data
✓ Monitor extension usage and manage themes
✓ Access browser tabs

Learn more about permissions

Facebook Container

No Facebook Trackers Detected

Facebook Container did not detect any Facebook trackers on this page. However, the page may still contain other types of trackers.

How Facebook Container Works ›

Sites Allowed in Facebook Container ›

Allow Site in Facebook Container

Fight Facebook with Firefox. And also fight all the other tracking cookie spaffers.

They would have you believe that this isn't enough and that the extra layer of encryption is a benefit. That's debatable since modern TLS 3 using Galois Fields and Elliptic curves is already difficult to crack.

Server operators can (if they keep and look at logs) see the IP address of every machine that sends their machine a request. And this is where VPNs are effective since these logs will only show the VPN server's address. That doesn't mean the originating IP address is impossible to figure out though. Browser-based video and voice communications are powered through the wonders of the WebRTC (Real-Time Communication) protocol.

Since most people are behind some sort of router or a firewall (and indeed perhaps a VPN too), it's generally not possible to establish a peer-to-peer connection through which to route all this traffic. So WebRTC uses intermediary STUN (Session Traversal Utilities for NAT) servers to exchange public and private IP addresses, and establish a connection. So with just a few lines of JavaScript, a web server operator can tell clients' originating IP addresses. Even if they're behind a VPN or other proxy.

GIVING WEBRTC THE HEAVE-HO

It's easy to work around this by disabling WebRTC in your browser settings, or even just disabling the address-exchanging part, but that hasn't stopped some unscrupulous operations from advertising their "WebRTC-leak" protection as some sort of value add. Some even have the audacity to claim a VPN will help stop Google and Facebook (or any other service that stores a login cookie) from tracking you around the web. What they don't say is that if you're signed into such an account, they will track you around the web. You're effectively telling them, "Hey it's me, I'm using this VPN's IP address now." To mitigate that risk, we can't recommend Mozilla's Firefox container add-on enough. This isolates browser cookies into different containers, so you can at least keep your casual browsing separate from your banking. There's a dedicated Facebook Container add-on if you want to evade Meta Corp's invasive tracking.

It's worth noting that attacks on VPN appliances (such as those provided by Fortinet and Pulse Secure) are on the rise. In April 2021, attackers were able to gain access to dozens of organizations in the defense industry. A coordinated security response (and a US Department of Homeland Security advisory) was able to mitigate the damage in this case, but as we rely on VPNs to protect our workplace secrets, it's a matter of when, not if, there will be further attacks.

And there ends our study of the VPN threatscape. We don't mean to tar all VPN providers with the same brush. It's just that we hate to see honest surfers deceived by scaremongering and faux-security advice. And we're tired of all the sponsored product-placing they do on our favorite YouTube channels. If you trust your VPN provider, please let us know who they are and why you trust them. ⏻

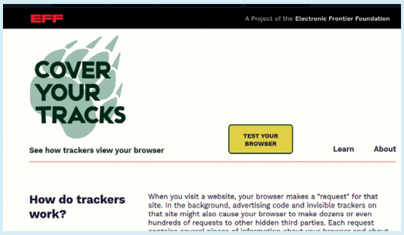
BROWSER FINGERPRINTING

We've seen that there are other ways users can be identified besides their IP address. One we haven't yet discussed in detail is browser fingerprinting. Even without recourse to the User Agent string, which can easily be falsified, everyone's browser, it turns out, behaves a little bit uniquely.

Specifically, different fonts (or JavaScript-constructed canvas elements) will render slightly differently on different systems with different resolutions. Likewise, everyone has their own WebGL attributes and their own set of headers that any old web page can happily request.

All of these variables can be measured, and there's sufficient variety that by studying a handful of metrics, website operators can uniquely fingerprint your browser.

The Tor Browser takes steps to block browser fingerprinting, with the goal that all Tor Browser users appear more or less identical. You can also use the EFF's Privacy Badger browser plugin, which blocks domains known to perform digital fingerprinting. The popular NoScript add-on can help too, but this interferes with a lot of sites' functionality. Browser add-ons themselves can also become part of the fingerprinting process so, in practice, it's difficult to avoid this identity leakage.



EFF

A Project of the Electronic Frontier Foundation

COVER YOUR TRACKS

See how trackers view your browser

TEST YOUR BROWSER

Learn

About

How do trackers work?

When you visit a website, your browser makes a "request" for that site. In the background, advertising code and invisible trackers on that site might also cause your browser to make dozens or even hundreds of requests to other hidden third parties. Each request

Check out the EFF's Cover Your Tracks site to see how unique your browser is.

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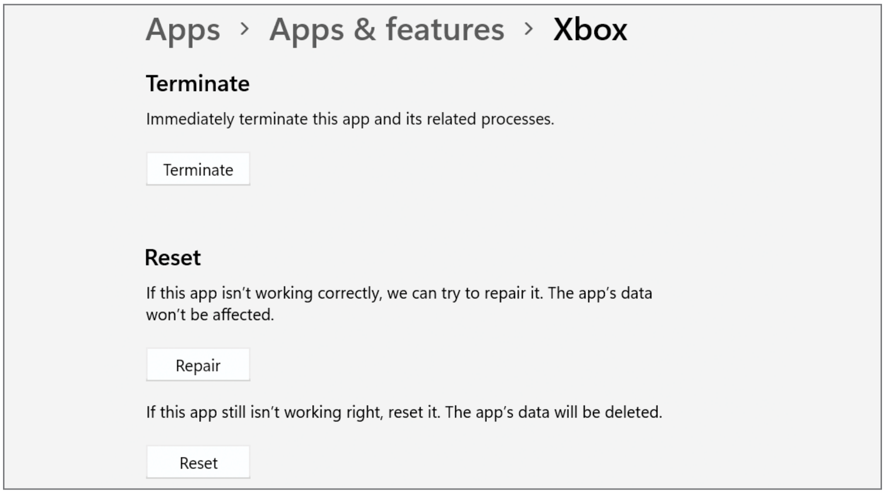
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH



Apps › Apps & features › Xbox

Terminate

Immediately terminate this app and its related processes.

Reset

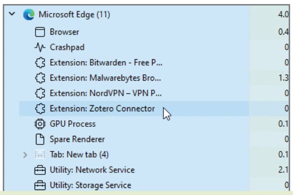
If this app isn't working correctly, we can try to repair it. The app's data won't be affected.

If this app still isn't working right, reset it. The app's data will be deleted.

XBOX APP FIX

If the Xbox app isn't loading, or you are unable to download your selected titles, there are several things you can do. First, head to the date & time settings and sync your time. Then, head to the apps & features menu, find the Xbox app, click on the three dots. Select advanced options, then scroll down and click on repair. If this doesn't fix the problem, hit reset and this should resolve these issues.

MAKE – USE – CREATE



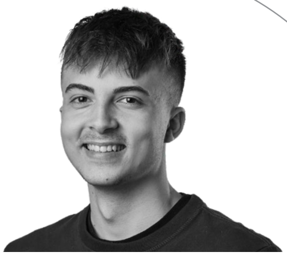
Microsoft Edge (11)	4.0
Browser	0.4
Crashpad	0
Extension: Bitwarden - Free P...	0
Extension: Malwarebytes Bro...	1.3
Extension: NordVPN – VPN P...	0
Extension: Zotero Connector	0
GPU Process	0.1
Spare Renderer	0
Tab: New tab (4)	0.1
Utility: Network Service	2.1
Utility: Storage Service	0

60
Hints and tips to keep Windows 11 running smoothly.

64
The Tandy TRS-80 Color Computer, an American classic.

66
Colorize vintage pics using GIMP editing software.

© XBOX, MICROSOFT, WIKIPEDIA, GIMP



SAM LEWIS
STAFF WRITER

HANDS-FREE ENTERTAINMENT

The Amazon Echo Auto has helped me and my girlfriend out by modernizing her car. She wanted to be able to make and receive phone calls and also play music wirelessly, but her infotainment was a little outdated and didn't come with Bluetooth support.

The Echo Auto sorted this out. It turns on whenever you start the ignition and seamlessly connects to your phone—it has eight mics so it can hear you over the sound of the car. If you have a 12-volt outlet and an auxiliary input, you too can have hands-free music streaming and calling.

Alexa aside, this past month I've been playing some more titles with the Xbox Game Pass. I have a PC hooked up to a 120Hz projector which is more than capable of smooth gaming. Paired with an Xbox One controller, this makes for a console-like experience with the added benefit of a huge display, the graphic sliders cranked to the right, and 120Hz smooth gameplay. *Maneater* is a bizarre open-world Jaws-like game where you play as a bull shark and gradually evolve through the storyline.

It's strange, but the cartoon graphics are impressive. I have also gotten into the *Doom* series on Game Pass. It's been fun to play these on the big screen, nearly 30 years after their release.

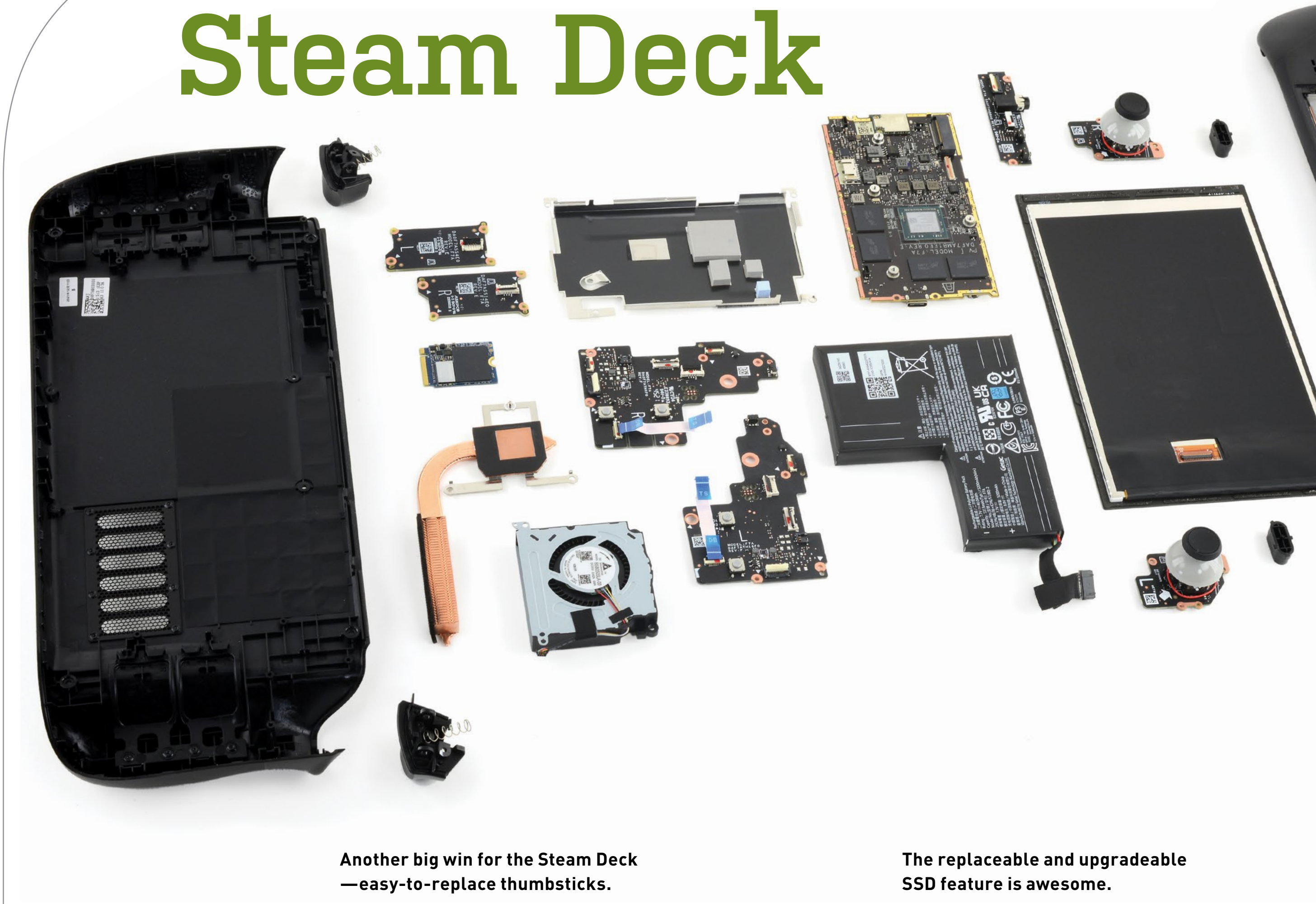
↘ submit your How To project idea to: editor@maximumpc.com

IFIXIT presents:

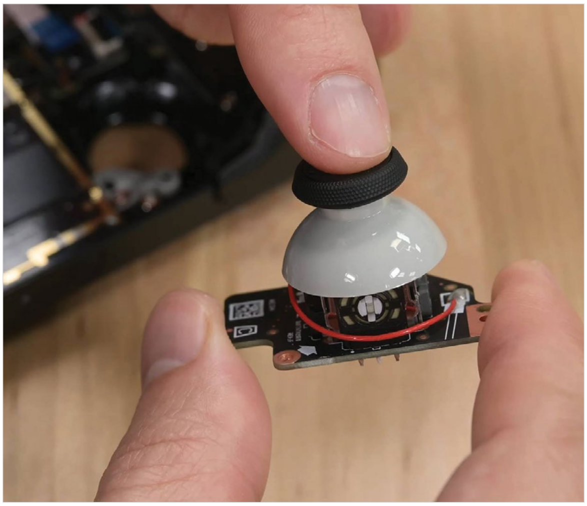
AUTOPSY

THIS MONTH WE DISSECT...

Steam Deck



Another big win for the Steam Deck—easy-to-replace thumbsticks.



The replaceable and upgradeable SSD feature is awesome.

PHISON
PS5013-E13-35
C02128E
TCYX48.00188

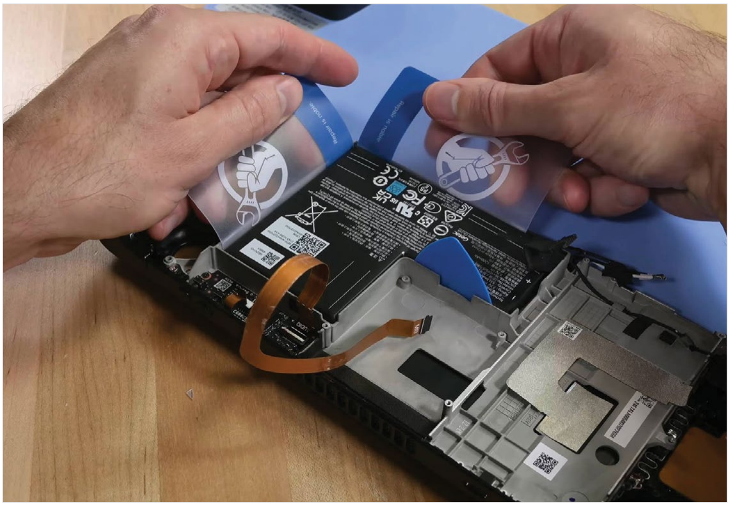
About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com

The hottest new device right now is the Steam Deck, a handheld gaming PC from Valve.

There are just eight Phillips screws holding the machine together.

Use heat to soften the adhesive and pry it out from the bottom edge—just watch out for the antenna hardware.



BACKGROUND

There have been other attempts to make a handheld PC games console, but none as high-profile or as cheap as Valve's Steam Deck.

MAJOR TECH SPECS

- AMD Zen 2 CPU with 4-cores/8-threads and a clock speed of 2.4–3.5GHz.
- AMD RDNA 2 GPU with 8 compute units and a clock speed of 1–1.6GHz.
- 16GB LPDDR5 RAM, with either 64GB eMMC, 256GB NVMe or 512GB NVMe SSD storage.
- 7-inch LCD touchscreen with 1280x800 pixel display and 60Hz refresh rate.
- 40Whr battery, USB-C port with charging and DisplayPort 1.4 support, Wi-Fi, Bluetooth, and 3.5mm audio jack.
- Dimensions: 11.7 x 4.6 x 1.8-inches (298 x 117 x 49mm), Weight: 1.47 lbs (669g).

KEY FINDINGS

- First of all, Valve should be applauded for offering this level of accessibility and upgradeability on its hardware. With just a little experience of PC building, you should be able to crack this thing open—though Valve warns that doing so will make the device more prone to drop damage. Valve has clearly labeled each internal component, which helps the repair process.

- Easily replaceable items include the thumbsticks, storage, and motherboard items such as RAM. The battery and display aren't so easy. The battery could be the Steam Deck's Achilles' Heel—it lasts as little as 90 minutes playing demanding games, meaning you could be going through plenty of recharge cycles.

- If there's one reason to open your Steam Deck, it's to upgrade the storage. But the microSD card slot is externally accessible, so you might want to try that first. If you do want to upgrade or replace the SSD, you can remove the M.2 2230 drive with a single screw. Just remember to reinstall the thin shield to prevent interference with the wireless receiver underneath.

- The thumbsticks are held in with three screws each—loosen these and they come right out. No soldering is a big deal for hardcore gaming fans who may experience drift over time. Replacements should be available at some point in the future.

- Battery replacement is tricky, even for seasoned hardware fixers. It's fiddly, requires specialist tools, and has the potential to damage your hardware. Drain the battery, then apply heat to soften the adhesive and pry it out. Isopropyl alcohol would make this easier, but any leaks could damage the display. The battery is an L-shaped model with two cells, like the iPhone X.

- The screen is also tricky to replace but, hopefully, you won't need to. To do so, apply heat to the outside, apply a suction cup to the screen and use a plastic tool to make an incision in the adhesive under the bezel. The anti-glare etched glass coating makes it difficult for the suction cup to maintain a grip.

- There are other minor gripes about upgradeability. The USB-C charging port and the microSD slot are both soldered to the main board—the former can get damaged over time, especially on a device that needs to be charged as frequently as this.

- Repairability Score 7 out of 10 (10 is the easiest to repair). Valve's repairability guides warn of danger when opening up the Steam Deck, but as long as you're sensible, you have nothing to worry about. Valve has prioritized the right components for repairability, such as the SSD drive and the thumbsticks. The real shocker is how difficult it is to repair the battery. However, props to Valve for giving every model of Steam Deck the same internal components—even if you opt for the budget model, you can still give it a substantial upgrade down the line.

Advanced Windows 11 tips: Task Manager

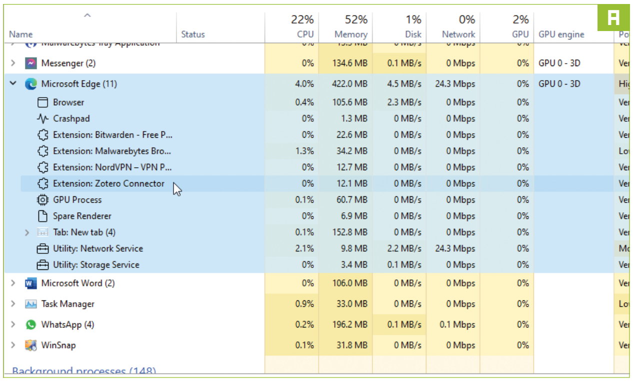
YOU'LL NEED THIS

ANY WINDOWS PC
Process Explorer (https://docs.microsoft.com/en-us/sysinternals/downloads/process-explorer)

IN THIS FIRST TUTORIAL in a new series showcasing how to get more from your Windows 11 setup, we're starting with a detailed look at what's going on under the hood of your machine. You may not currently care that, behind the scenes, your Windows installation is performing a complicated juggling routine involving a tangled web of applications, services, processes, threads, and handles, but we suspect that outlook will change the moment your system starts to slow down, become non-responsive, or prone to crashing.

Knowledge is power, and there are two primary tools that can help you peer behind the scenes to determine what's going on, identify areas of concern, and even in some cases, restore non-responsive applications to life without force-quitting them and losing hours of unsaved work. The first, Task Manager, is built into Windows itself and has all the tools you need to resolve most problems, but if you need an even deeper dive into your PC's software innards, then Process Explorer is the tool for you.

Armed with these tools, you'll discover how to monitor and free up system resources, track down troublesome processes, and generally keep your PC running a bit more smoothly. So, without further ado, let's pull back the curtain... **–NICK PEERS**



Name	Status	22% CPU	52% Memory	1% Disk	0% Network	2% GPU	GPU engine	Po
Messenger (2)		0%	134.6 MB	0.1 MB/s	0 Mbps	0%	GPU 0 - 3D	Ver
Microsoft Edge (11)		4.0%	422.0 MB	4.5 MB/s	24.3 Mbps	0%	GPU 0 - 3D	Hi
Browser		0.4%	105.6 MB	2.3 MB/s	0 Mbps	0%		Ver
Crashpad		0%	1.3 MB	0 MB/s	0 Mbps	0%		Ver
Extension: Bitwarden - Free P...		0%	22.6 MB	0 MB/s	0 Mbps	0%		Ver
Extension: Malwarebytes Bro...		1.3%	34.2 MB	0 MB/s	0 Mbps	0%		Lo
Extension: NordVPN – VPN P...		0%	12.7 MB	0 MB/s	0 Mbps	0%		Ver
Extension: Zotero Connector		0%	12.1 MB	0 MB/s	0 Mbps	0%		Ver
GPU Process		0.1%	60.7 MB	0 MB/s	0 Mbps	0%		Ver
Spare Renderer		0%	6.9 MB	0 MB/s	0 Mbps	0%		Ver
Tab: New tab (4)		0.1%	152.8 MB	0 MB/s	0 Mbps	0%		Ver
Utility: Network Service		2.1%	9.8 MB	2.2 MB/s	24.3 Mbps	0%		Mc
Utility: Storage Service		0%	3.4 MB	0.1 MB/s	0 Mbps	0%		Ver
Microsoft Word (2)		0%	106.0 MB	0 MB/s	0 Mbps	0%		Ver
Task Manager		0.9%	33.0 MB	0 MB/s	0 Mbps	0%		Lo
WhatsApp (4)		0.2%	196.2 MB	0.1 MB/s	0.1 Mbps	0%		Ver
WinSnap		0.1%	31.8 MB	0 MB/s	0 Mbps	0%		Ver

Background processes (148)

1 QUICK-FIRE ORIENTATION

Let's start with a quick tour of Task Manager's key features. Step one is opening it—the quickest way is to learn a new three-fingered salute if you haven't already: Ctrl + Shift + Esc (save Ctrl + Alt + Delete for times when Windows won't respond). You can also access Task Manager in Windows 10 by right-clicking the Taskbar, or in Windows 11 by right-clicking the Start button and choosing Task Manager.

» The basic Task Manager view is a simple list of running apps, so in the unlikely event you haven't already gone beyond this, click 'More details' to access a more reassuringly packed seven-tabbed dialog packed with useful info. The annotation provides a quick overview of what each section does, but let's take a deep dive and see what each section can provide in terms of useful diagnostic info and troubleshooting tools.

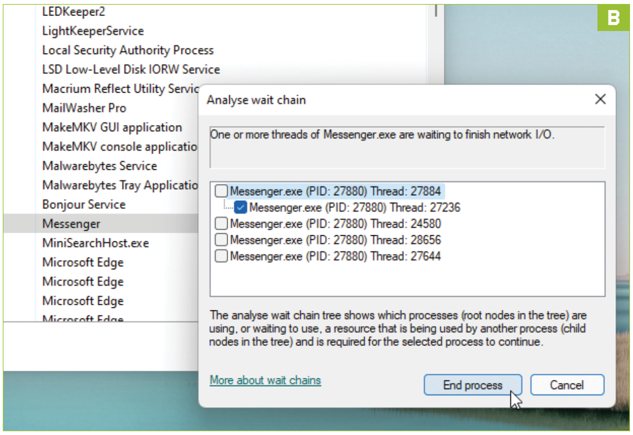
2 SEE WHAT'S RUNNING

The Processes tab is where you'll get a detailed overview of what's running on your PC. It's split into three sections: Apps lists the programs you've launched via File Explorer—to see what processes each app is running, click the → next to its entry to expand the list. In most cases, there may only be a single process listed, or you may simply see multiple threads with the same name as the app itself, but others may provide more useful details. For example, Word will display a separate entry for each document you've opened, while Microsoft Edge goes even further in identifying each separate subprocess [**Image A**].

» Beneath Apps lies 'Background processes', which lists all third-party programs running in the background. Again, some can be expanded, and these may provide more pertinent information about the process, or at least which program launched it. For example, expand 'Anti-malware Service Executable' to discover that it is part of Microsoft Defender's Antivirus component.

» The final section is 'Windows processes', which refers to core processes related to Windows, including all running Services. The latter can also be viewed via their own dedicated tab, but one of the benefits of using Processes is that you can review each individual process's resource usage, with columns covering CPU, Memory, Disk, and Network. Click a column header to quickly sort the list by which process is taking up the most resources.

» To find out more about a process, right-click it and choose Properties → Details tab or choose 'Search



LEDKeeper2
LightKeeperService
Local Security Authority Process
LSD Low-Level Disk IORW Service
Macrium Reflect Utility Servic
MailWasher Pro
MakeMKV GUI application
MakeMKV console applicatio
Malwarebytes Service
Malwarebytes Tray Applicatio
Bonjour Service
Messenger
MiniSearchHost.exe
Microsoft Edge
Microsoft Edge
Microsoft Edge

Analyse wait chain

One or more threads of Messenger.exe are waiting to finish network I/O.

☐ Messenger.exe (PID: 27880) Thread: 27884
  ☑ Messenger.exe (PID: 27880) Thread: 27236
☐ Messenger.exe (PID: 27880) Thread: 24580
☐ Messenger.exe (PID: 27880) Thread: 28656
☐ Messenger.exe (PID: 27880) Thread: 27644

The analyse wait chain tree shows which processes (root nodes in the tree) are using, or waiting to use, a resource that is being used by another process (child nodes in the tree) and is required for the selected process to continue.

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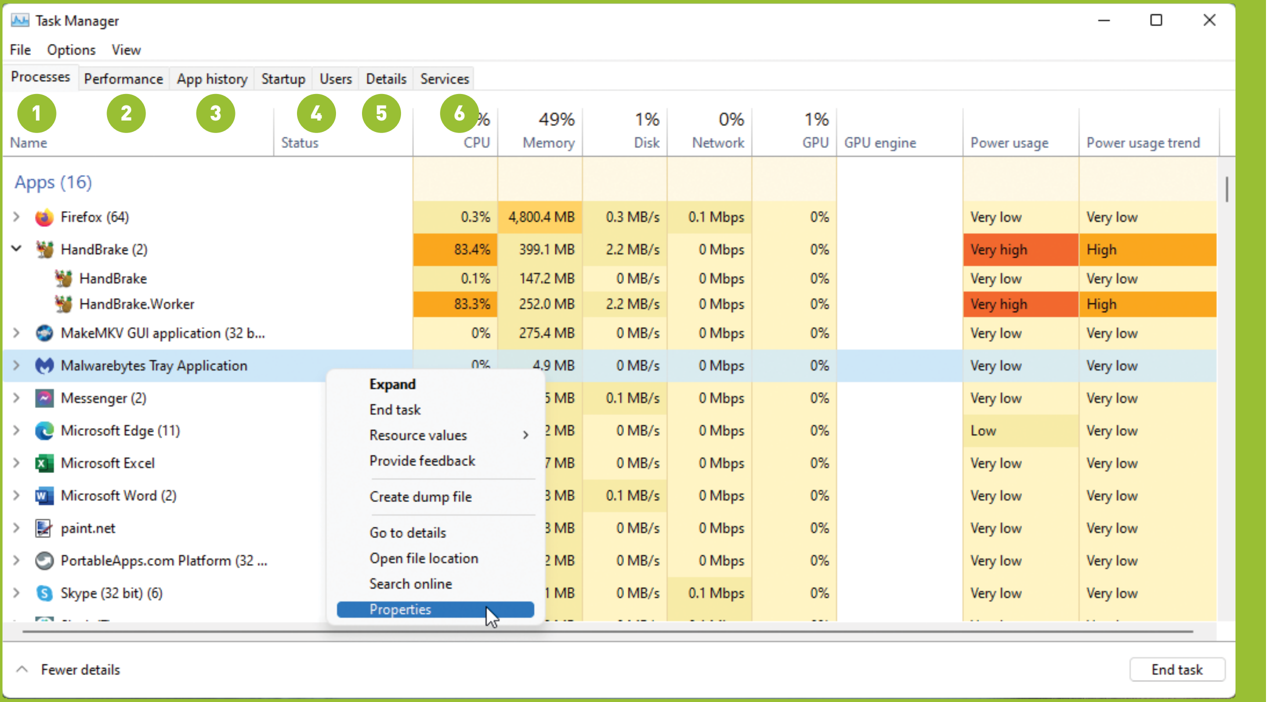
TASK MANAGER AT A GLANCE



Name	Status	% CPU	49% Memory	1% Disk	0% Network	1% GPU	GPU engine	Power usage	Power usage trend
Apps (16)									
Firefox (64)		0.3%	4,800.4 MB	0.3 MB/s	0.1 Mbps	0%		Very low	Very low
HandBrake (2)		83.4%	399.1 MB	2.2 MB/s	0 Mbps	0%		Very high	High
HandBrake		0.1%	147.2 MB	0 MB/s	0 Mbps	0%		Very low	Very low
HandBrake.Worker		83.3%	252.0 MB	2.2 MB/s	0 Mbps	0%		Very high	High
MakeMKV GUI application (32 b...		0%	275.4 MB	0 MB/s	0 Mbps	0%		Very low	Very low
Malwarebytes Tray Application		0%	4.9 MB	0 MB/s	0 Mbps	0%		Very low	Very low
Messenger (2)			5 MB	0.1 MB/s	0 Mbps	0%		Very low	Very low
Microsoft Edge (11)			2 MB	0 MB/s	0 Mbps	0%		Low	Very low
Microsoft Excel			7 MB	0 MB/s	0 Mbps	0%		Very low	Very low
Microsoft Word (2)			3 MB	0.1 MB/s	0 Mbps	0%		Very low	Very low
paint.net			3 MB	0 MB/s	0 Mbps	0%		Very low	Very low
PortableApps.com Platform (32 ...			2 MB	0 MB/s	0 Mbps	0%		Very low	Very low
Skype (32 bit) (6)			1 MB	0 MB/s	0.1 Mbps	0%		Very low	Very low

1. PROCESSES
This tab offers a handy view of everything—from Store apps and desktop programs to background services—running on your PC. Items are split into three sections: Apps, Background processes, and Windows Processes.

2. PERFORMANCE
From here, you can monitor the performance of key hardware. A chart provides historic data for the past 60 seconds, while you also get to see real-time stats and key info about each component.

3. APP HISTORY/STARTUP
While the former provides a means of monitoring the resource usage of any running apps you've installed through the Microsoft Store, the latter offers a comprehensive list of programs and apps set to start with Windows, complete with a rough estimate of their impact on start-up times.

4. USERS
If multiple users are logged on to your PC, use this tab to see what processes each user is currently running. Of course, this will be of limited use to single users.

5. DETAILS
Potentially the most useful part of Task Manager, this section provides you with information—and control—over running processes.

6. SERVICES
Get a quick overview of running Services. You can start and stop them from here or jump to the more fully-featured Services tool.

online' to perform a Bing-powered search for both the process name and its underlying filename. If you're troubleshooting an app, choose 'Create a dump file' to create a file you can share with a professional or review yourself using the free WinDbg Preview (install this through the Microsoft Store).

3 RECOVER FROZEN APPS

One major use of Task Manager is, of course, ending non-responsive programs or processes to free up your PC. You'll be aware that such processes are usually highlighted and selecting the process and clicking the 'End task' button (sometimes more than once) is usually enough to end it. One exception is File Explorer (or Windows Explorer as it's listed)—when you select this, 'End task' is replaced by a 'Restart' button, which does what it says on the tin.

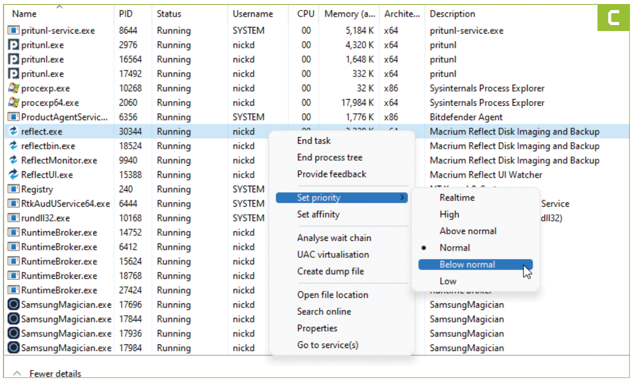
» But what if you're about to potentially lose a load of data because you've been lax about saving documents? With a bit of luck, you may be able to recover the program by identifying and terminating the exact thread holding things up, which may be enough to coax the app back to life without crashing.

» To do this, right-click the errant process and choose 'Go to details' to switch to the Details tab where you'll find processes are listed alphabetically with lots more potentially useful info: their status (running or suspended), the user who launched them (typically you, SYSTEM or a SERVICE) and a PID (Process ID).

» To try and free up a non-responding thread from here, right-click it again and choose 'Analyze wait chain'. This will list any threads that are using or waiting to use resources being used elsewhere [**Image B**]. Ending the thread may be enough to free up the original process—we've done this a few times in Firefox when an individual tab has become non-responsive, for example.

4 OPTIMIZE APP PERFORMANCE

There are some other handy options under the Details tab—you can alter thread priorities here, which in turn can stop particular processes from taking over your PC and slowing everything else down. This is more an issue with low-powered PCs (in which



Name	PID	Status	Username	CPU	Memory (a...	Archite...	Description
pritunl-service.exe	8644	Running	SYSTEM	00	5,184 K	x64	pritunl-service.exe
pritunl.exe	2976	Running	nickd	00	4,320 K	x64	pritunl
pritunl.exe	16564	Running	nickd	00	1,648 K	x64	pritunl
pritunl.exe	17492	Running	nickd	00	332 K	x64	pritunl
procexp.exe	10268	Running	nickd	00	32 K	x86	Sysinternals Process Explorer
procexp64.exe	2060	Running	nickd	00	17,984 K	x64	Sysinternals Process Explorer
ProductAgentServic...	6356	Running	SYSTEM	00	1,776 K	x86	Bitdefender Agent
reflect.exe	30344	Running	nickd				Macrium Reflect Disk Imaging and Backup
reflectbin.exe	18524	Running	nickd				Macrium Reflect Disk Imaging and Backup
ReflectMonitor.exe	9940	Running	nickd				Macrium Reflect Disk Imaging and Backup
ReflectUI.exe	15388	Running	nickd				Macrium Reflect UI Watcher
Registry	240	Running	SYSTEM				
RtkAudUService64.exe	6444	Running	SYSTEM				Service
rundll32.exe	10168	Running	SYSTEM				dll32)
RuntimeBroker.exe	14752	Running	nickd				
RuntimeBroker.exe	6412	Running	nickd				
RuntimeBroker.exe	15624	Running	nickd				
RuntimeBroker.exe	18768	Running	nickd				
RuntimeBroker.exe	27424	Running	nickd				
SamsungMagician.exe	17696	Running	nickd				SamsungMagician
SamsungMagician.exe	17844	Running	nickd				SamsungMagician
SamsungMagician.exe	17936	Running	nickd				SamsungMagician
SamsungMagician.exe	17984	Running	nickd				SamsungMagician

case, take a look at Process Lasso (https://bitsum.com/) for an automated solution), but if you'd like to experiment, right-click the offending process and choose 'Set Priority → Below Normal' to see if it helps to rein in resource hogs [**Image C**]. You can also give threads more priority if you feel they need extra attention but avoid giving any thread 'Realtime' priority as it will bring Windows grinding to a halt.

» Another option is 'Set affinity'. This may have performance benefits for older programs designed during the days of single-core processors—the setting basically allows you to limit an app to using specific processor cores—but in most cases, Windows knows what it's doing, so is largely redundant.

5 MONITOR PERFORMANCE

The Performance tab allows you to monitor the effect your currently running system is having on key hardware components: CPU, RAM, disks, network, and GPU are all covered. You get a graph providing you with 60 seconds of past performance [**Image D**], plus key stats about current resource usage as well as some handy info about the component in

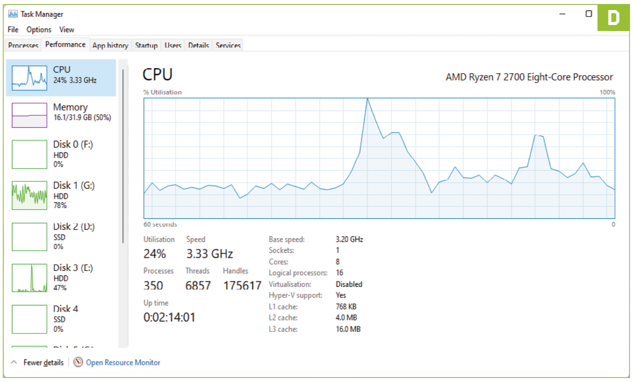
TERMINOLOGY 101

Throughout Task Manager and Process Explorer, you'll find references to programs, processes, handles, and threads. What do they mean and how do they relate to each other?

Programs are sets of files required to run an application, whether it's a game, web browser, underlying Windows programs, such as File Explorer, or background Services.

Processes provide the resources required to run the executable program. These are stored in a reserved portion of RAM (physical and virtual) known as 'virtual address space', and include the program files, plus open 'handles' to system objects. They're assigned a security context, which determines their level of access to the system, a unique process identifier (PID) for identification, memory limits ('working set sizes'), and a priority class, which determines how fast they can run in relation to other processes.

Handles determine what resources each process requires (such as DLL files or Registry entries), as well as environment variables. Each process is then split into threads, which allows Windows to allocate processor time between them. Each **thread** can execute any part of the process's code—even parts being executed by other threads—and shares the process's virtual address space and resources. They have their own properties, such as unique identifiers and exception handlers, and are designed to stop and start to a schedule, so they don't all run at once.



Task Manager
File Options View
Processes Performance App history Startup Users Details Services

CPU 24% 3.33 GHz
Memory 16.1/31.9 GB (50%)
Disk 0 (F:) HDD 0%
Disk 1 (G:) HDD 78%
Disk 2 (D:) SSD 0%
Disk 3 (E:) HDD 47%
Disk 4 SSD 0%

CPU
AMD Ryzen 7 2700 Eight-Core Processor

Utilisation 24%
Speed 3.33 GHz
Processes 350
Threads 6857
Handles 175617
Up time 0:02:14:01

Base speed: 3.20 GHz
Sockets: 1
Cores: 8
Logical processors: 16
Virtualisation: Disabled
Hyper-V support: Yes
L1 cache: 768 KB
L2 cache: 4.0 MB
L3 cache: 16.0 MB

question (for example, whether hardware virtualization is currently enabled for your CPU).

» If you'd like to monitor the cumulative effects of individual apps in terms of CPU (processor time used) and network (amount of data transferred), then switch to the 'App history' tab. By default, it only shows apps installed through the Microsoft Store but you can change this to show all processes by selecting 'Options → Show history for all processes'. To reset the stats and start recording again, click 'Delete usage history'.

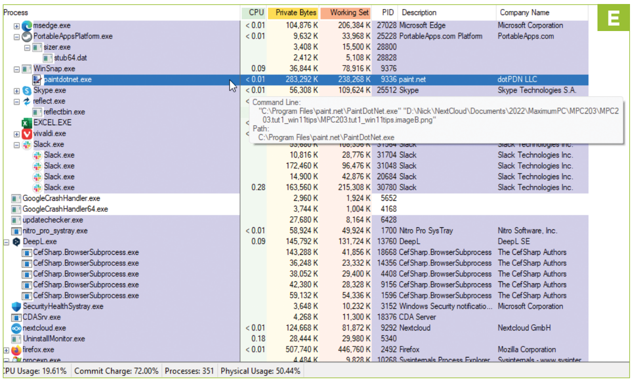
6 STREAMLINE START-UP

It's amazing what apps configure themselves to automatically start with your PC. Task Manager's Startup tab provides a comprehensive view of what's set itself to start with Windows—even apps missed by third-party tools like BootRacer. Better still, Task Manager offers a 'Start-up impact' rating for each app to help you identify those taking the most resources, although it frequently, and disappointingly, lists 'Not measured' next to many. Click the 'Start-up impact' column header to sort the list to show those with a high impact first.

» Most apps configure themselves to start with Windows simply to save a bit of time when you launch them, so if you rarely use the app, select it and click the Disable button to shave seconds from startup as well as reclaim memory and CPU resources.

7 DETERMINE PROCESS RELATIONSHIPS

Task Manager can tell you a lot about individual processes, but one thing it doesn't do is demonstrate how they're interconnected. To dig even deeper into what's running on your PC, we recommend Process Explorer, a free tool from Microsoft's Sysinternals team. No installation is required, simply



Process	CPU	Private Bytes	Working Set	PID	Description	Company Name
msedge.exe	< 0.01	104,876 K	206,384 K	27028	Microsoft Edge	Microsoft Corporation
PortableAppsPlatform.exe	< 0.01	9,632 K	33,968 K	25228	PortableApps.com Platform	PortableApps.com
sizer.exe		3,408 K	15,500 K	28800		
stub64.dat		2,412 K	5,108 K	28828		
WinSnap.exe	0.09	36,844 K	78,916 K	9376		
paintdotnet.exe	< 0.01	283,292 K	238,268 K	9336	paint.net	dotPDN LLC
Skype.exe	< 0.01	56,308 K	109,624 K	25512	Skype	Skype Technologies S.A.
reflect.exe						
reflectbin.exe						
EXCEL.EXE						
vivaldi.exe						
Slack.exe						
Slack.exe		10,816 K	28,776 K	31704	Slack	Slack Technologies Inc.
Slack.exe		172,460 K	96,476 K	31048	Slack	Slack Technologies Inc.
Slack.exe		14,900 K	42,876 K	20684	Slack	Slack Technologies Inc.
Slack.exe	0.28	163,560 K	215,308 K	30780	Slack	Slack Technologies Inc.
GoogleCrashHandler.exe		2,960 K	1,924 K	5652		
GoogleCrashHandler64.exe		3,744 K	1,004 K	4168		
updatechecker.exe		27,680 K	8,164 K	6428		
nitro_pro_systray.exe	< 0.01	58,924 K	49,924 K	1700	Nitro Pro SysTray	Nitro Software, Inc.
DeepL.exe	0.09	145,792 K	131,724 K	13760	DeepL	DeepL SE
CefSharp.BrowserSubprocess.exe		143,288 K	41,856 K	18668	CefSharp.BrowserSubprocess	The CefSharp Authors
CefSharp.BrowserSubprocess.exe		36,248 K	23,332 K	14356	CefSharp.BrowserSubprocess	The CefSharp Authors
CefSharp.BrowserSubprocess.exe		38,052 K	29,400 K	4408	CefSharp.BrowserSubprocess	The CefSharp Authors
CefSharp.BrowserSubprocess.exe		42,380 K	28,328 K	9156	CefSharp.BrowserSubprocess	The CefSharp Authors
CefSharp.BrowserSubprocess.exe		59,132 K	54,336 K	1596	CefSharp.BrowserSubprocess	The CefSharp Authors
SecurityHealthSystray.exe		3,648 K	10,232 K	3152	Windows Security notificatio...	Microsoft Corporation
CDASrv.exe		4,268 K	11,300 K	18376	CDA Server	
nextcloud.exe	< 0.01	124,668 K	81,872 K	9292	Nextcloud	Nextcloud GmbH
UninstallMonitor.exe	0.18	28,444 K	29,980 K	5340		
firefox.exe	< 0.01	507,740 K	446,760 K	2492	Firefox	Mozilla Corporation

Command Line:
"C:\Program Files\paint.net\PaintDotNet.exe" "D:\Nick\NextCloud\Documents\2022\MaximumPC\MPC203\MPC203.tut1_win11tips\MPC203.tut1_win11tips.imageB.png"
Path:
C:\Program Files\paint.net\PaintDotNet.exe

PU Usage: 19.61% | Commit Charge: 72.00% | Processes: 351 | Physical Usage: 50.44%

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download ProcessExplorer.zip from https://docs.microsoft.com/en-us/sysinternals/downloads/process-explorer and then extract the ProcessExplorer folder from inside it. Open this and you'll find three executables to choose from: procexp.exe contains both 32-bit and 64-bit versions, so right-click this and choose 'Run as administrator'.

» Process Explorer opens to display a colorful, multi-columned window that's like Task Manager's Details view. One difference is that processes are nested inside other processes. This provides a breadcrumb trail of what program spawned what, helping you identify where specific processes came from.

» Scroll down the list and you'll see a host of familiar programs appearing under explorer.exe – any program opened in the usual way (via the desktop, Taskbar, or Start menu) will appear here. If you subsequently opened a program via another program, then the target program, Paint.NET in the example shown [**Image E**], will appear nested inside its parent, which is WinSnap here.

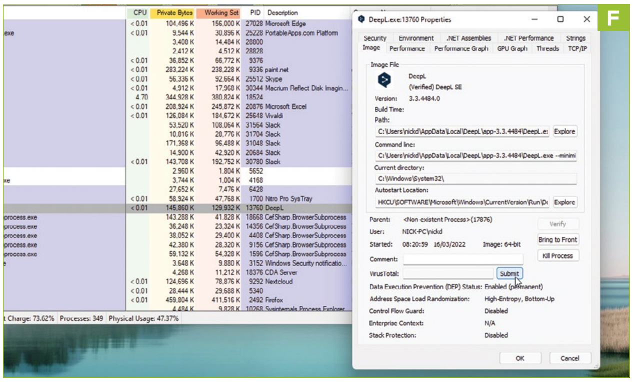
» The color coding helps identify what's going on with each process—choose Options → Configure Colors… to see what each color represents. You'll notice most processes under explorer.exe are lilac, or 'Own Processes', which means they're running under the same account as Process Explorer, typically your own. Keep an eye out for purple processes, these 'Packed Images' may contain compressed code, a possible sign of malware.

8 GET A GRANULAR VIEW

Even when you lose the multi-nested view in Process Explorer, you can still identify which parent a process belongs to by double-clicking it to open a comprehensive, multi-tabbed Properties dialog. You'll open to the Image tab, where the process is listed along with its parent, which user it's running under, its autostart location (if relevant), and even the command line argument used to launch it. The Image tab also provides controls for confirming the validity of a program's digital signature (click Verify) as well as an option to submit the file to VirusTotal for a quick malware check—recommended if the process is colored purple [**Image F**].

» Other useful tabs include Performance, Performance Graph, and GPU Graph for measuring that process's specific use of resources. Visit the TCP/IP tab to monitor what remote network connections, if any, a process is using. You can even see what environment variables a process has set up via the Environment tab, which often provides more clues to its origins.

» One of the many ways in which Process Explorer allows you to see what's really happening under the hood is through its support for showing detailed information about a process's threads. Switch to the Thread tab—ignoring the warning about missing symbol files—and you'll see a list of all threads associated with that process. You get to see the CPU usage for individual threads as well as the files calling that thread, which helps pinpoint where a resource leak may be occurring. You can technically kill or suspend individual threads from here, but save any work before doing so – you could easily bring down the parent process, or even Windows itself, if you don't know what you're doing.


F

	CPU	Private Bytes	Working Set	PID	Description
	< 0.01	104,496 K	156,000 K	27028	Microsoft Edge
exe	< 0.01	9,544 K	30,896 K	25228	PortableApps.com Platform
		3,408 K	14,484 K	28800	
		2,412 K	4,512 K	28828	
	< 0.01	36,852 K	66,772 K	9376	
	< 0.01	283,224 K	238,228 K	9336	paint.net
	< 0.01	56,336 K	92,664 K	25512	Skype
	< 0.01	4,912 K	17,968 K	30344	Macrium Reflect Disk Imagin…
	4.70	344,928 K	380,824 K	18524	
	< 0.01	208,924 K	245,872 K	20876	Microsoft Excel
	< 0.01	126,084 K	184,672 K	25648	Vivaldi
		53,520 K	108,064 K	31564	Slack
		10,816 K	28,776 K	31704	Slack
		171,368 K	96,488 K	31048	Slack
		14,900 K	42,920 K	20684	Slack
	< 0.01	143,708 K	192,752 K	30780	Slack
		2,960 K	1,804 K	5652	
xe		3,744 K	1,004 K	4168	
		27,652 K	7,476 K	6428	
	< 0.01	58,924 K	47,768 K	1700	Nitro Pro SysTray
	< 0.01	145,860 K	129,932 K	13760	DeepL
process.exe		143,288 K	41,828 K	18668	CefSharp.BrowserSubprocess
process.exe		36,248 K	23,324 K	14356	CefSharp.BrowserSubprocess
process.exe		38,052 K	29,400 K	4408	CefSharp.BrowserSubprocess
process.exe		42,380 K	28,320 K	9156	CefSharp.BrowserSubprocess
process.exe		59,132 K	54,328 K	1596	CefSharp.BrowserSubprocess
e		3,648 K	9,880 K	3152	Windows Security notificatio…
		4,268 K	11,212 K	18376	CDA Server
	< 0.01	124,696 K	78,876 K	9292	Nextcloud
	< 0.01	28,444 K	29,688 K	5340	
	< 0.01	459,804 K	411,516 K	2492	Firefox
		4,484 K	9,828 K	10268	Sysinternals Process Explorer

Charge: 73.62% Processes: 349 Physical Usage: 47.37%

DeepL.exe:13760 Properties

DeepL
(Verified) DeepL SE
Version: 3.3.4484.0
Build Time:
Path: C:\Users\nickd\AppData\Local\DeepL\app-3.3.4484\DeepL.e
Command line: C:\Users\nickd\AppData\Local\DeepL\app-3.3.4484\DeepL.exe --minimi
Current directory: C:\Windows\System32\
Autostart Location: HKCU\SOFTWARE\Microsoft\Windows\CurrentVersion\Run\D
Parent: <Non-existent Process>(17876)
User: NICK-PC\nickd
Started: 08:20:59 16/03/2022 Image: 64-bit
Comment:
VirusTotal:
Data Execution Prevention (DEP) Status: Enabled (permanent)
Address Space Load Randomization: High-Entropy, Bottom-Up
Control Flow Guard: Disabled
Enterprise Context: N/A
Stack Protection: Disabled

9 HANDLES AND DLL FILES

Process Explorer also lets you take a close look at a process's handles and DLL files, which are the resource files that can be shared between multiple programs. Select your thread and press Ctrl + H—a new pane will appear listing its handles. From here, double-click a handle to get more information about it (most specifically, a description of the handle type, such as 'Section' or 'WindowStation'). It's technically possible to close individual handles by right-clicking and choosing the 'Close' option, but as with threads, if you don't know what you're doing, it's likely you'll bring the whole process crashing down.

» Press Ctrl + D and the lower pane switches to DLL view, listing all the DLL files that the process in question is accessing. Double-click a DLL file to access its Properties—switch to the Strings tab and you'll be shown a list of string values it contains. Press Ctrl + H to switch back to Handles view, or Ctrl + L to toggle the lower pane on and off.

» What does this information tell you? It gives you detailed insights into what makes up a process—how it's made up of multiple threads and what resources it uses in the forms of handles and DLL files. Not only does it let you see what's happening with individual processes, it also helps you learn how programs and processes run.

» Handles are also useful for identifying which process is preventing you from deleting a file because it's open elsewhere. Choose 'Find → Find Handle or DLL' and enter the name of the offending file. Click Search, and a list of processes using the file will be displayed. Closing these should allow you to delete the file. ⏻

ANOTHER WINDOWS 11 TUTORIAL NEXT MONTH

TRACK YOUR SYSTEM

If you'd like to keep Process Explorer running in the background, click Options to open the menu and tick both 'Hide When Minimized' and 'Allow Only One Instance'. This means you'll always be able to access Process Explorer from the Taskbar notification area, plus you'll prevent multiple instances of the app from running.

Process Explorer's icon displays a real-time chart of CPU usage—roll your mouse over it and a pop-up will display overall CPU usage as a percentage along with the most demanding process currently running. You can alter these metrics via Options → Tray Icons. Choices include GPU memory and Commit, which gives you an estimate of how much memory your system may need based on its current usage. If your system appears sluggish, you can glance at this then open Process Explorer for a wider view.

Look carefully at the System process. You'll see an entry marked 'Interrupts'. This is an artificial process that tracks the system's interaction with your hardware. If you spot high CPU consumption for this figure, then it indicates a potential problem with your hardware or, more likely, a driver bug. Don't bother clicking it for further information, though—there's nothing to see, literally.

Tandy TRS-80 Color Computer (1980)

YOU'LL NEED THIS

A COPY OF VCC
Downloads are provided on the project's GitHub page. Extra system ROMs not required.
https://github.com/VCCE/VCC/releases

THIS MONTH we explore a true American classic: the TRS-80 Color Computer, otherwise known as "CoCo" for short. Not to be confused with the original TRS-80 manufactured in the late 1970s, the CoCo was to be a new system for the 1980s, designed to take on Apple and Commodore with something more affordable, and in color no less.

The CoCo provides a sizeable library for any 8-bit enthusiasts. Unfortunately, running this software can be a tricky process, so we will guide you through the steps needed to emulate this groundbreaking machine. –**JOHN KNIGHT**

1 DEVELOPMENT AND RELEASE

The CoCo began life as a VideoTex terminal designed to provide farmers with access to real-time agricultural information. The VideoTex terminal used Motorola's Video Display Generator (VDG) chip and 6809 processor. Although the VideoTex was commercially unsuccessful, in 1980, it was combined with newer hardware to form the basis of a new color computer.

» Tandy removed the VideoTex's internal modem and added expansion for ROM cartridges, cassette input, serial I/O, and joystick ports. Video output was based around a standard TV set.

» The first TRS-80 Color Computer launched in September 1980, for an introductory price of $399. Although the base model was quite cheap, the system relied heavily on expensive peripherals and users even had to supply their own tape drive.

» Despite its name, the CoCo shares nothing in common with the original TRS-80 and is not backward compatible.

» The CPU is a Motorola 6809E clocked at 0.895MHz. Sound is basic, being handled by a single-channel 6-bit DAC, powered by the CPU. Graphically impressive for the time, the CoCo is capable of nine colors and a maximum resolution of 256x192.

» The base specs provided 4KB of RAM and Color BASIC, a Tandy implementation of Microsoft BASIC, in an 8KB ROM.

» Models with 16KB (and later 32KB) of RAM were also available, with the option of Extended Color BASIC.

2 SOFTWARE

The CoCo software library has a different emphasis from many systems. It featured better educational software than Commodore's machines, though its limited 32-column text mode meant the machine wasn't suited to business applications.

» For anyone looking to get into BASIC programming, the CoCo is an excellent place to start. There are plenty of books and magazine listings, and Tandy's own 'Getting Started With Color BASIC' manual was considered one of the best in the business.

» For some gaming highlights, *Dungeons of Daggorath* (1982) is a particularly famous first-person dungeon crawler, with real-time gameplay and unique line graphics. *Skiing* (1980) is a personal favorite—its first-person 3D perspective is surprisingly effective, despite the machine's graphical limitations. *Zaxxon* (1983) is a solid port and one of the system's better titles.

» Other games included *Time Bandit* (1983), *Speed Racer* (1984), and *Pitfall 2* (1985), which is a great update on a classic. For titles that push the system harder, check out *Thexder* (1987), *Springster* (1987), *King's Quest III* (1988), and *Rampage* (1989).

» Most software titles and reference manuals can be found at the excellent colorcomputerarchive.com website.

3 LEGACY

In 1983, the CoCo was upgraded to the Color Computer 2. These new models brought drastic price reductions and featured either 16 or 64KB of RAM.

» The case was re-designed: consolidated chipsets allowed for a smaller footprint, and the iconic silver styling was replaced by beige. Later models, named the Tandy Color Computer 2, featured full-travel keyboards.

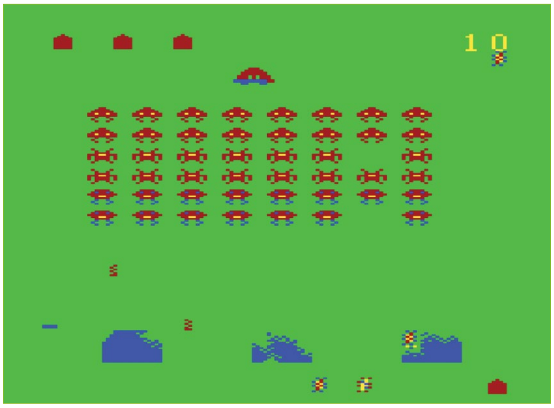
» In 1986, the Color Computer 3 pushed CoCo architecture to its limits. A newer variant of the 6809 CPU allowed for twice the clockspeed and the CoCo came with 128KB as standard, upgradeable to 512KB.

» The Advanced Color Video Chip allowed features such as memory bank switching, RGB output, 80 column text, 16 colors on screen from a palette of 64, and resolutions up to 640x192. Extra keyboard buttons were added, cursor keys were grouped in a more conventional layout, and more priority was given to Microware's OS-9.

» In October 1990, Tandy discontinued the line, though stores continued to sell CoCo stock. As for how many they sold, Tandy was notoriously tight-lipped on figures.

4 EMULATION

The easiest emulator is VCC, which emulates the CoCo 3, but its interface can be obtuse. VCC only supports Windows, but Linux users can run VCC through Wine or OVCC. Still, it can be a pain to install. You can try MAME, though you will need system ROMs.



» **CoCo games have a strange color palette. *Color Space Invaders* (1981) has a green background instead of black.**

© COCO GAMES

» **The Tandy TRS-80 may have had a cheap and nasty keyboard, but that classic silver case was just so darned cool!**

© WIKIPEDIA

TROUBLESHOOTING

If your programs load in black and white, you can change to color by pressing F6. Or you can open VCC's Options window, select the Display tab, and choose Composite instead of RGB. If you want to use a joystick, you might consider an old-fashioned flight-sim joystick with analog controls. The original Tandy joysticks were nasty devices that used analog positioning and didn't auto-center.

In some games, a modern controller may result in large jumps across the screen, even when using an analog thumbstick. It may be awkward, but you might consider using the mouse for certain titles.

» The VCC's Github page provides a self-extracting Windows executable, with a simple installer interface that will automatically create entries in your system menu.

» Once you open the application, we recommend switching VCC's keyboard layout to a modern PC key mapping, otherwise entering BASIC commands will be a nightmare.

» From the main menu, choose Configuration → Config. In the new Options window, open the Keyboard tab, and in the Select Keyboard Mapping field, click Natural. There, it's worth opening the Joysticks tab to define how you will control your games.

5

LOADING CARTRIDGES

Unlike the other storage mediums, loading cartridges is easy. Just choose Cartridge → Cartridge → Load Cart.

» Select your cartridge image from the file browser, and the emulator will reset, loading the cartridge automatically.

6

LOADING TAPES

Loading tapes isn't difficult, but it is unintuitive. Open the Options window by selecting Configuration → Config, then open the Tape tab. Click Browse to open a cassette image file, then click Apply. It's worth keeping the Options window open and moving it to one side because you'll need to use it again.

» Click on the main window, and in the BASIC prompt, enter:

```
CLOADM
```

» The emulated Tandy will now wait for you to press Play on the tape recorder—in the Options window. Press Play and the BASIC prompt will flash an F character to indicate the program is loading. Once finished, the prompt says "OK", and has a blinking cursor.

» To run the program, enter:

```
EXEC
```

7

LOADING DISKS

When it comes to loading disks, VCC's method is bonkers. This also requires BASIC commands.

» On the original CoCo, disk drives connected via a cartridge interface, so VCC does something similar. When you first start VCC, there will be no apparent way to load disks. But if you load a cartridge, the file browser opens in VCC's installation folder, with the file fd502.dll.

» When you open the Cartridge menu, there will be a series of floppy drive sub-menus called FD-502. Load a disk in the first drive by clicking Cartridge → FD-502 Drive 0 → Insert. Select your file and you'll be taken back to the emulator screen.

» To load a program, browse the disk and look for the filename. Browse the first floppy drive by entering:

```
DIR 0
```

» In the output that follows, look for either BAS (basic programs) or BIN (binary programs) files. If there are any BASIC programs, try loading these first.

» To load a BASIC program, enter the command:

```
RUN "0:BOOT.BAS"
```

» We used BOOT.BAS as an example, but replace this filename with whatever you have on your disk image.

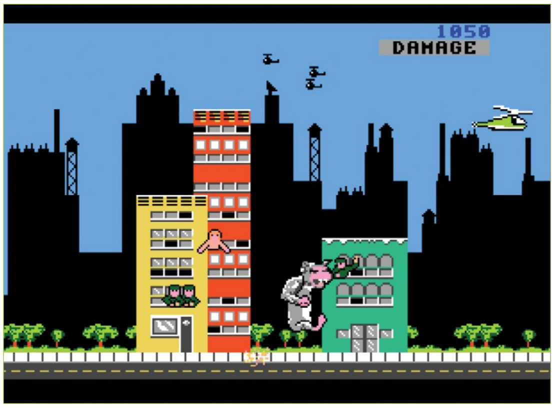
» If there are no BASIC programs, run a binary program by entering (using Zaxxon as an example):

```
LOADM "0:ZAXXON.BIN" : EXEC
```

SPECIFICATIONS

Tandy TRS-80 Color Computer (1980)

CPU:	Motorola 6809E @ 0.895 / 1.79MHz
RAM:	4KB–64KB, 128KB–512KB
Graphics:	Motorola 6847 VDG, 256x192 maximum resolution, 9 maximum colors
Sound:	6-bit DAC
Storage:	ROM cartridge, cassette, 5.25-inch floppy
OS:	Color BASIC, Extended Color BASIC, OS-9
Launch Price:	$399
Released:	September 1980
Production:	1980–1990, 1991
Worldwide sales:	N/A



» **Games such as *Rampage* (1989) for the CoCo 3 are more sophisticated and benefit from its two-button fire mode.**

GIMP color restoration

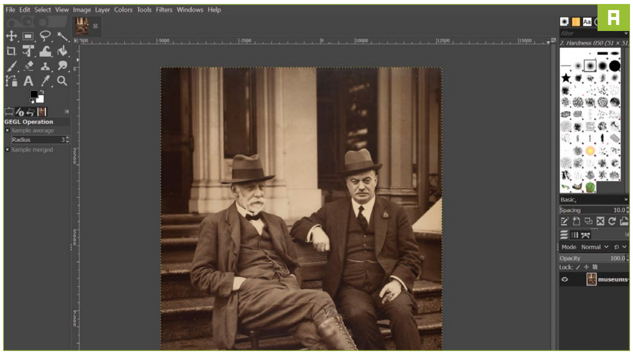
YOU'LL NEED THIS

GIMP 2.1
OS: Windows 7 or newer

OVER THE PAST YEAR OR SO, we've featured a variety of image manipulation tutorials that have covered a range of tasks. These programs are often powerful tools, but they also tend to cost a fair amount. Our go-to photo-editing program is usually Adobe Photoshop, but this can be a pricey tool, particularly if it comes as part of a subscription to the Adobe suite. However, there are plenty of alternatives, such as GIMP, that offer a similar outcome for free.

Although it doesn't have the most instantly appealing name, GIMP is an acronym for GNU Image Manipulation Program. Granted, this application doesn't have the finesse and the overall shine that Photoshop does, but it's still a useful program, particularly for those on a budget or just starting out. If you're unsure on what path you'd like to take in design, whether that's as a hobbyist or if you want to take the commercial route, then GIMP is a great free starting point.

In this tutorial, we will be using this program to restore and recolor old black and white photographs. This is a common practice that can truly breathe life into old pictures. It's a great skill to learn and apply to some old family images of your own. –**SAM LEWIS**



1 PAST TIMES

Kicking things off, you need to have a starting image. As we said earlier, using an old family picture could be a solid place to start as you can get to see or imagine how life used to be back in those times. If your photo is in the original black and white format, it can often be hard to imagine this.

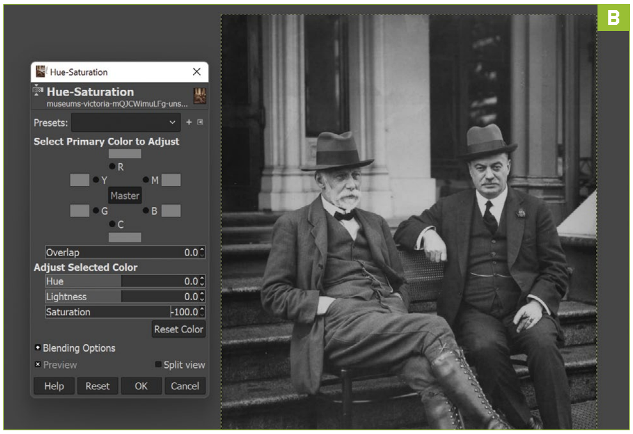
» For our example, we will be practicing using the free image licensing site, Unsplash [www.unsplash.com]. If you also don't have a personal image you can use, Unsplash is very handy for testing out our tutorials.

» With our image selected, we need to open this up inside the GIMP program. There are a few ways to do so; File then Open, CTRL+O, or you can use the old faithful drag and drop method. We're going to be using a photo by Museums Victoria on Unsplash. This image features two photography pioneers from Kodak Australasia, Thomas Baker and JJ Rouse [**Image A**]. It's also a sepia tone image so before we begin, we actually need to take away the color before we can add it back.

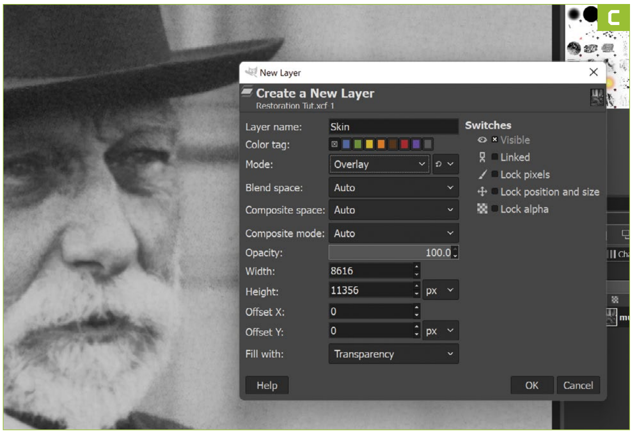
» Head to the top and click on the colors menu and select hue-saturation. A pop-up window will open revealing a variety of color settings [**Image B**]. Slide the saturation all the way to the left to remove the color and this will leave you with a black and white photo. Of course, if you are starting with a black and white image, then you can skip this step.

2 DIFFERENT TONES

Now we're ready with our image, we need to bring the color in, or re-imagine it. To make things easier and more organized, split the image up into parts that will feature the same color. The first thing we will tackle is the skin tones [**Image C**]. Websites such as Color Hunt [https://colorhunt.co/] make finding colors



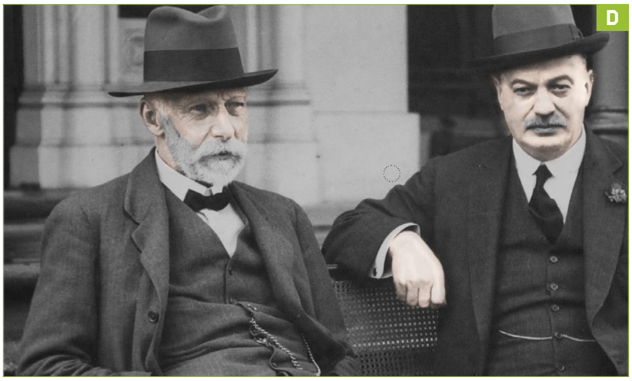
Hue-Saturation
museums-victoria-mQJCWimuLFg-uns...
Presets:
Select Primary Color to Adjust
Overlap 0.0
Adjust Selected Color
Hue 0.0
Lightness 0.0
Saturation -100.0
● Blending Options
☒ Preview ☐ Split view



Create a New Layer
Restoration Tut.xcf-1
Layer name: Skin
Color tag: ☒ 🟦 🟩 🟨 🟧 🟫 🟥 🟪 ⬛
Mode: Overlay
Blend space: Auto
Composite space: Auto
Composite mode: Auto
Opacity: 100.0
Width: 8616
Height: 11356 px
Offset X: 0
Offset Y: 0 px
Fill with: Transparency

Switches
☒ Visible
☐ Linked
☐ Lock pixels
☐ Lock position and size
☐ Lock alpha

© MUSEUMS VICTORIA ON UNSPLASH



and palettes easy, so we chose our skin tone palette from the site and added it into our document.

›› For each segment, create a new layer. When making the layer, a pop-up will open, so select 'overlay' in the mode section. This will allow the detail to show through the color we are going to paint on. Sample one of the skin tones using the color picker tool in the top left section of the workspace. This tool can also be used by pressing the 'O' key [**Image D**].

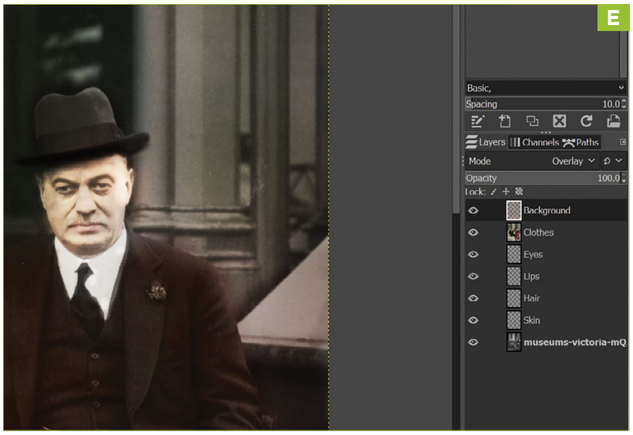
›› In this new layer, we're going to start by using the brush tool to paint an outline of the areas we're focusing on, then we will fill in this gap by increasing the brush tool size. Take your time to work around the image. We started on the hands and then moved onto the face—be careful to not go over any facial hair or the eyes, as these will be two separate layers.

3 LAYERS UPON LAYERS

GIMP works in a similar way to Photoshop, in that you have the majority of your tools towards the left-hand side of the artboard and your layers are located on the right.

›› To help through this project, make sure to label all of your layers [**Image E**]. This will make sure you keep the colors separate. Also, keep altering the brush settings. You can change the opacity to weaken or strengthen the color you're applying. The same can be said for the brush hardness. It's best to use a soft brush when working around the edges of different colors where they meet.

›› Another point to mention is that when selecting your colors, try to be as accurate as possible, or period correct. This is quite tricky and of course, if the image is your own, it will make this a lot easier. If not, find images on Google of something similar; hair colors, clothing items, materials, and more to replicate them in your image. Work your way around the picture bit by bit and gradually it will all come together.



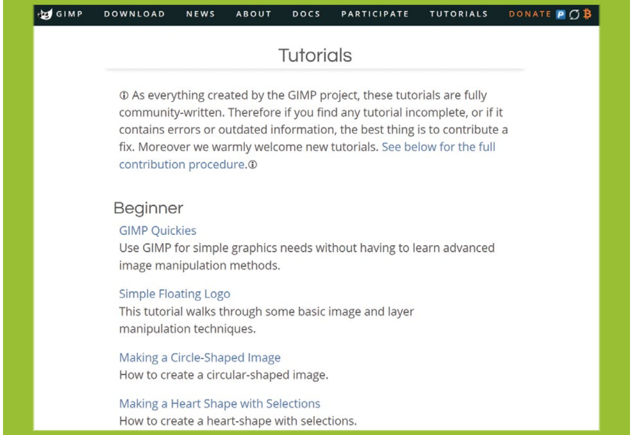
Spacing 10.0

Mode Overlay

Opacity 100.0

© GIMP

THE GIMP PAGE



Tutorials

ⓘ As everything created by the GIMP project, these tutorials are fully community-written. Therefore if you find any tutorial incomplete, or if it contains errors or outdated information, the best thing is to contribute a fix. Moreover we warmly welcome new tutorials. See below for the full contribution procedure.ⓘ

Beginner

GIMP Quickies
Use GIMP for simple graphics needs without having to learn advanced image manipulation methods.

Simple Floating Logo
This tutorial walks through some basic image and layer manipulation techniques.

Making a Circle-Shaped Image
How to create a circular-shaped image.

Making a Heart Shape with Selections
How to create a heart-shape with selections.

If you're unfamiliar with GIMP, the best place to head to first is the official website. Here, you can download the latest version (2.10.30) and learn about this open-source program. For beginners, it makes sense to use this application to see whether photo manipulation is something you can do and that you enjoy before you spend a dime.

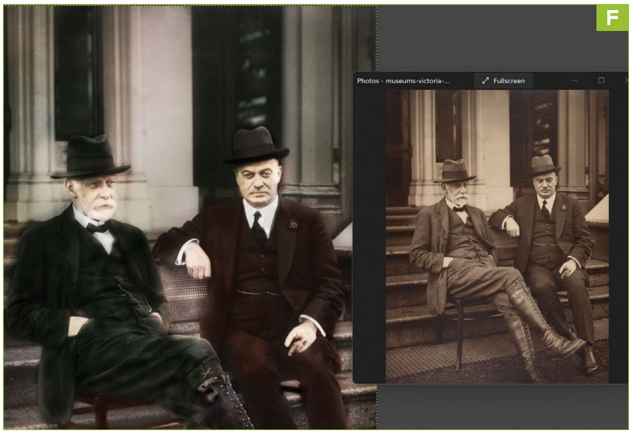
You can also head to the tutorials section if you're just starting from scratch. These are simple, yet informative lessons that give you a full rundown on the application and how to get to grips with it. Like most things, it can be quite daunting to use a new program, but the more and more you use it, the easier it gets to work your way around it.

Switching to GIMP from Photoshop was actually a fairly easy transition. The layout and tool selection is similar to the offering from Adobe, so if you're following our path, don't fear. GIMP is a great tool everyone should try out.

4 SPLASH OF COLOR

This is by no means an easy process but, with these tutorials, you can understand how to alter these images and hopefully use this skill to bring some life into some personal images of your own.

›› Our image still maintains the 'old style' as the overlay mode keeps the grainy detail [**Image F**]. This is what you want to try to retain, as you aren't aiming to completely modernize these old images, just add a splash of color that gives them a new dimension. ⏻



Organize notes for free with Joplin

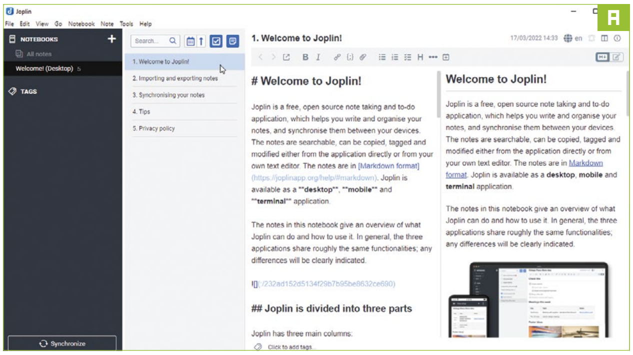
YOU'LL NEED THIS

JOPLIN
(https://joplinapp.org)
Plus supported cloud service for syncing your notes.

WE SPENT MANY A YEAR EXPERIMENTING with note-taking tools, looking for the perfect cross-platform service. And then we stumbled on Joplin (https://joplinapp.org/). It's completely free to use, open-source, and works across all major desktop and mobile platforms, so you can easily access and update your notes from anywhere.

Joplin is perfect whether you're looking to record basic text-only notes or emulate the rich text features found in paid-for products, such as Evernote—from markdown-styled text to support for embedding images and even file attachments. You can type directly into the app or capture notes from the web using the free Joplin add-in for your web browser—available for Firefox and any browser with access to the Chrome web store.

When it comes to syncing notes, you're in complete control. You can sign up for Joplin's new cloud-based platform or sync for free through your existing cloud storage account. Worried about security? You can also wrap your notes in an added layer of encryption for additional protection. Put simply, Joplin is everything you ever wanted in a note-taking tool—we've not looked at another platform since discovering it three years ago. Read on for our guide on how to start using it. **–NICK PEERS**


A
Joplin
File Edit View Go Notebook Note Tools Help
NOTEBOOKS
All notes
Welcome! (Desktop) 5
TAGS
Synchronize
Search...
1. Welcome to Joplin!
2. Importing and exporting notes
3. Synchronising your notes
4. Tips
5. Privacy policy
1. Welcome to Joplin!
17/03/2022 14:33
en
Click to add tags...

# Welcome to Joplin!

Joplin is a free, open source note taking and to-do application, which helps you write and organise your notes, and synchronise them between your devices. The notes are searchable, can be copied, tagged and modified either from the application directly or from your own text editor. The notes are in [Markdown format](https://joplinapp.org/help/#markdown). Joplin is available as a **desktop**, **mobile** and **terminal** application.

The notes in this notebook give an overview of what Joplin can do and how to use it. In general, the three applications share roughly the same functionalities; any differences will be clearly indicated.

![](:/232ad152d5134f29b7b95be8632ce690)

## Joplin is divided into three parts

Joplin has three main columns:

Welcome to Joplin!

Joplin is a free, open source note taking and to-do application, which helps you write and organise your notes, and synchronise them between your devices. The notes are searchable, can be copied, tagged and modified either from the application directly or from your own text editor. The notes are in Markdown format. Joplin is available as a **desktop**, **mobile** and **terminal** application.

The notes in this notebook give an overview of what Joplin can do and how to use it. In general, the three applications share roughly the same functionalities; any differences will be clearly indicated.

1 FIRST STEPS

The best place to download Joplin is from https://joplinapp.org/help/#installation, where you'll find convenient links for all desktop platforms (macOS, Linux, and Windows) and a portable version for Windows. You'll also find links to the Android and iOS mobile apps plus the Web Clipper page to obtain the browser plugin for Firefox and any browser capable of accessing the Chrome Web Store, including Edge, Opera, and Vivaldi, as well as Chrome itself.

2 A QUICK TOUR

After installation, launch Joplin for the first time on your PC. You'll see how Joplin organizes your notes using two panes on the left of its main window.

» On the far left is a list of notebooks, with a section beneath called Tags, which will provide you with another way to categorize and filter your notes as their number grows. A 'Welcome' notebook is set up by default, and you'll see a list of five notes next to it, each providing a handy introduction to how Joplin works [**Image A**].

» You'll see the main view on the right-hand side—by default, a split-screen offering an edit window on the left and a preview window on the right. Press Ctrl + L to switch between split-screen, editor, and preview pane views. Work your way through the five notes to understand how Joplin works.

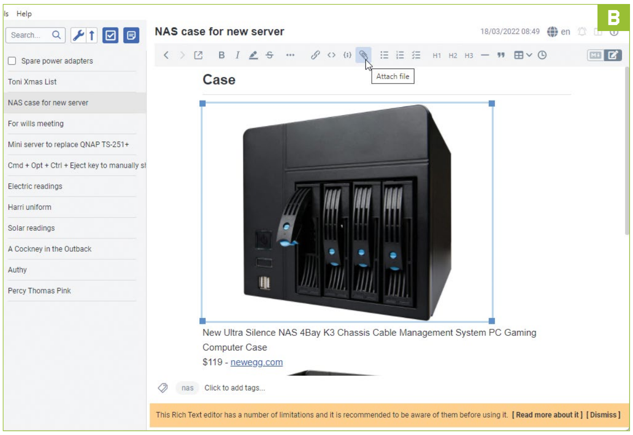
3 YOUR FIRST NOTE

Click + next to Notebooks to create your first notebook. Give it a suitably descriptive title and click 'Select emoji' or 'Select file...' to assign it an icon if you wish before clicking OK.

» You can nest notebooks inside other notebooks (right-click an existing notebook and choose 'New notebook' to do so) for an even greater level of organization.

» Select your new notebook, and you'll be prompted to add your first note using one of the two blue buttons next to the Search box at the top of the notes list. The right-hand button creates a standard note, while on the left is a 'to-do' note, which is the same except a check box that allows you to mark it completed.

» A blank screen will await you, allowing you to compose your note in either plain text or formatted using a combination of the formatting controls at the top of the Editor pane as well as markdown formatting. As you type into the Editor pane, you'll see the Viewer pane update to display your text, including any formatting you've applied.


B
ls Help
Search...
☐ Spare power adapters
Toni Xmas List
NAS case for new server
For wills meeting
Mini server to replace QNAP TS-251+
Cmd + Opt + Ctrl + Eject key to manually sl
Electric readings
Harri uniform
Solar readings
A Cockney in the Outback
Authy
Percy Thomas Pink
NAS case for new server
18/03/2022 08:49
en
H1 H2 H3
Attach file
nas
Click to add tags...

Case

New Ultra Silence NAS 4Bay K3 Chassis Cable Management System PC Gaming Computer Case
$119 - newegg.com

This Rich Text editor has a number of limitations and it is recommended to be aware of them before using it. [Read more about it] [Dismiss]

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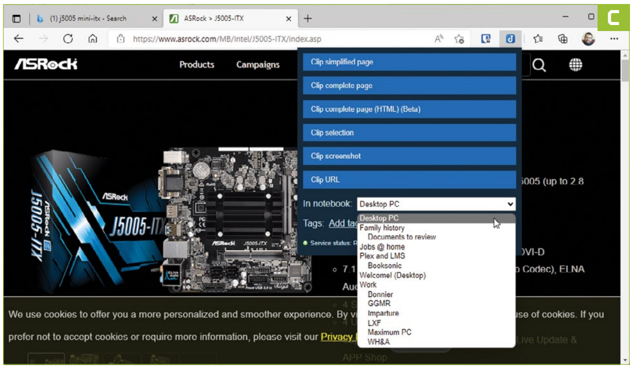
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Documents to review
Jobs @ home
Plex and LMS
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Maximum PC
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In notebook: Desktop PC

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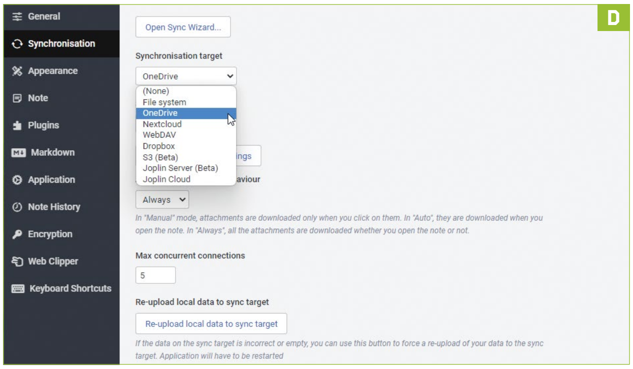
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(None)
File system
OneDrive
Nextcloud
WebDAV
Dropbox
S3 (Beta)
Joplin Server (Beta)
Joplin Cloud
Re-upload local data to sync target

Synchronisation target: OneDrive

Always

In "Manual" mode, attachments are downloaded only when you click on them. In "Auto", they are downloaded when you open the note. In "Always", all the attachments are downloaded whether you open the note or not.

Max concurrent connections: 5

Re-upload local data to sync target

If the data on the sync target is incorrect or empty, you can use this button to force a re-upload of your data to the sync target. Application will have to be restarted

4 STYLE YOUR NOTES

Markdown is a standard formatting language that ensures your notes can be styled in a way that is rendered the same across multiple devices and platforms. As with all coding, you compose your notes in plain text, but by using markdown formatting such as # Heading 1 or **This text is in bold**, your text is then formatted using compatible tools and viewers, including Joplin's own Viewer pane.

» Markdown doesn't take long to learn, and Joplin provides a handy list of common syntax at https://joplinapp.org/markdown/ plus you can expand its capabilities with the help of plug-ins (see box). While Joplin does provide a Rich Text editor, which combines both editor and viewer in a single view, it still uses Markdown behind the scenes and is less flexible than the traditional Markdown editor. Switch between editors using the buttons on the right of the formatting toolbar.

5 ATTACH IMAGES AND FILES

You can attach files to your notes. Either drag the file into your note from a File Explorer window or click the paperclip button to select it and a clickable link to the file will appear. If it's an image, that will be displayed. [**Image B**]. Hold Alt as you drag to create a link instead of displaying it. Once an image is in place, click to resize it and reposition it within the text.

6 CLIP WEB PAGES

Both Firefox and Chrome web browsers offer a free Web Clipper tool for generating notes from web pages. Open 'Tools → Web clipper options' in Joplin. Click 'Enable Web Clipper Service', then click the appropriate link to locate and add the extension for Chrome-based browsers and/or Firefox. You should see the Joplin icon appear in your browser's toolbar.

» Once set up, browse to a web page containing the content you want to use, then click the Joplin button to bring up a list of options [**Image C**]. You can clip the complete page (including a simplified note-friendly version) or choose to grab selected content, a screenshot of the page, or a URL. Choose a notebook to store the note in, give it a suitable name, add any keyword tags if required, and finally click Confirm.

7 SYNC AND ENCRYPT

Joplin works best across multiple desktop and mobile devices. For this to work, set up synchronization. Joplin's cloud solution (https://joplinapp.org/plans/) isn't free, so you may want to use your own cloud provider if you don't need additional features, such as publishing notes online or collaborating with others. Dropbox, OneDrive, Nextcloud, file system (a local network folder), Amazon S3, and WebDAV-compatible services are all supported.

» Navigate to Tools → Options → Synchronization. If you're using Joplin Cloud, Dropbox or OneDrive, click 'Open Sync Wizard...' and follow the prompts [**Image D**]; otherwise, select your 'Synchronization target' from the menu and fill in the blanks as required [**Image E-alt**].

» By default, notes are stored unencrypted, so choose 'Tools → Encryption options' and click 'Enable encryption' to protect them. You'll be prompted to set a master password, then click OK.

» When setting up Joplin on another device, choose to synchronize using the same online service. Any notes stored in the cloud will automatically be downloaded. Make sure you choose 'Tools → Encryption options' where you'll need to enter any master passwords from other devices to decrypt your synchronized notes. ⏻

EXPAND JOPLIN WITH PLUGINS

Joplin allows you to extend its feature set further using plugins, which provide all kinds of additional functionality. There are formatting plugins to expand Joplin's markdown support as well as tools for extending existing functions and adding new ones. For example, a 'Persist Editor Layout Plugin' allows you to set different editor/viewer layouts for specific notes, while 'Joplin Outline' provides a table of contents view for those notes structured using headers. You'll also find plugins designed to help perform batch jobs, such as Attaché, which can be used to quickly update all file attachments with their latest versions without having to reattach each one manually.

Joplin's Plugin Repository can be accessed via https://github.com/joplin/plugins. Scroll through the list to find any plugins of interest—use the homepage icon to visit the plugin's dedicated page for more information and instructions on using it. While you can download plugins directly from here, a more straightforward way to install the plugin is through Joplin: navigate to Tools → Options → Plugins, search for the plugin name, and click Install to add it to Joplin.

For more help and advice using individual plugins, visit Joplin's plugins discussion forum on Discourse (https://discourse.joplinapp.org/c/plugins/18).

LAB NOTES

GUY COCKER, EDITOR-IN-CHIEF

A Tale of Two Smartphones

Samsung vs Redmagic

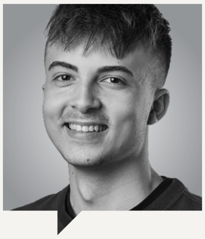
AWAY FROM THE WORLD of performance PCs, this month I played with two brand new powerhouse phones—the Samsung Galaxy S22 Ultra and the Redmagic 7 Pro. In the blue corner, Samsung brings a raft of premium features, including top-of-the-line cameras, the brightest phone screen ever, and the much-loved S Pen stylus. In the red corner, Redmagic offers gaming-optimized shoulder triggers, fast 960Hz touch sampling, and 18GB of RAM (that's more than in my gaming laptop, and that runs *God of War* at max settings).

While these two phones serve different audiences in the real world, I found that using them side-by-side played to my two conflicting interests in an almost Jekyll & Hyde manner. During the day, I love having the Samsung and its pen for making notes, a brilliant camera for taking product shots at events, and the DeX mode which allows it to become a PC wherever there's a monitor or TV. But when I was off the clock, I preferred the Redmagic and its ability to dominate in *Call of Duty Mobile* and play classic games via emulation.

I get there are compromises to be made on smartphones. The Redmagic's cameras are nowhere near as good as the Samsung's, while the S22 Ultra can't run *Genshin Impact* at a solid 60fps without the Redmagic's innovative fan-based cooling solution. However niche gaming smartphones are, I love that they exist. They're the reason I extricated myself from the Apple ecosystem last year, as I was sent Asus, Lenovo, and Black Shark gaming phones to review and was impressed with their 120Hz+ displays and raw performance.

Samsung or Redmagic? Decisions, decisions.

In the meantime, I'm going to have to make a decision on what to use as my daily driver and, because the Samsung allows me to be more productive, it will have to be the S22 Ultra. Boring old Dr. Jekyll wins again. Without the shoulder triggers of the Redmagic, though, the real victim is going to be my *Call of Duty Mobile* K/D ratio.



SAM LEWIS

Staff Writer

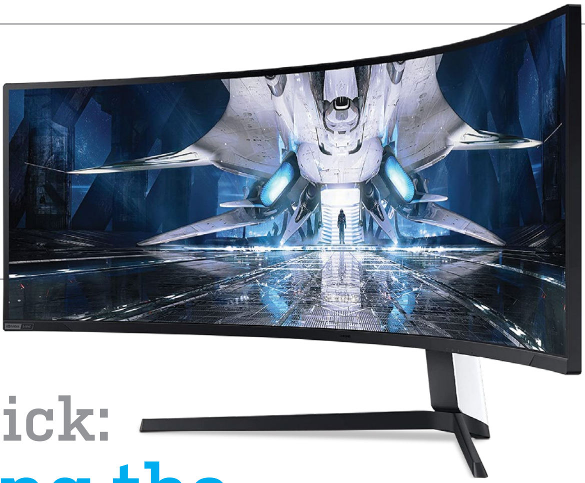
Since I was young, the idea of having a projector at home seemed far-fetched. I was wowed every time I went to the theater—there still isn't a better way to experience a film than on the big screen. Going to the movies was a great time in our childhoods and although I still go when I can, it's something that has slowed down due to, well, life.

So, when I had the chance to bridge the gap between watching movies at home and going to the movies by reviewing some projectors, you bet I was excited. The two particular models, the Asus H1 and XGIMI Halo+, have been well and truly tested in my household. In fact, I don't think I've turned the TV on in a while. By making some space in a spare room, I've made something of a cinema room that I've essentially been hibernating in. There's a certain feeling that you get from watching a series or movie through a projector that you don't get with a TV.

I've also been playing a few casual games by hooking up a gaming laptop to the projector, which sure is a different way to experience certain titles. It's not exactly ideal for high-octane FPS games, but for the slower-paced open-world titles, a projector gives you an immersive experience.

It's safe to say that when I next move house, I'll be looking at getting a more permanent projector set up to satisfy that need for the big screen experience.

© SAMSUNG, REDMAGIC



The latest firmware update has fixed most, but not quite all, of the Samsung's Neo G9 borkage.

Editor's Pick: Revisiting the Samsung Neo G9

Is OLED the future of PC displays?

FOR AN ANSWER to the question posed above, you'll have to wait for the next issue and our full review of the new Alienware AW3423DW QD-OLED panel, the first true OLED monitor for gamers.

But what I can say right now, however, is that Alienware has got me thinking. As I soaked up the incredible contrast, colors, and speed, the question was whether it made every gaming monitor that came before it redundant. Is it really that good? In some ways it is. But by other measures, it doesn't get off the starting line.

In size and resolution terms, it's an ordinary 34-inch monitor with a 3,440x 1,440 resolution. For pixel density, it is blown out of the water by any 4K gaming panel. Then there's sheer scale, which is where the troubled Samsung Neo G9 comes in. Sure, the Neo G9 was buggy at launch. But doesn't its preposterous 49-inch girth and incredible wrap-around 1000R curvature count for something?

OK, the Neo G9 is more expensive than the Alienware at $1,999. But if you're spending $1,299, you can probably afford $1,999. Plus, the original G9, which is identical save for slightly less advanced backlighting tech, can now be had for less than the Alienware OLED.

Anyway, what I'm getting at is that, currently, you can't have everything. You can have OLED, but not with a ton of pixels or a huge curved panel. So, if you had to choose between the OLED delights of the new Alienware panel and the epic scale of the G9, which should it be?

We reviewed the Neo G9 here with some serious issues, including an inability to get near the claimed 2,000 nit brightness, faulty HDR tone mapping, scanlines, and more. The latest firmware update addresses most of those issues. The panel can now hit well over 2,000 nits and the HDR tone mapping is fixed. However, some issues involving local dimming and SDR content remain. The scanline problems haven't been entirely fixed either.

All that makes it hard to recommend the Neo G9, but not impossible. Because, boy, when this thing is working right, it's stunning. The way it wraps around and dominates your field of view is special. With HDR working, it's also extraordinary in image quality terms. Bright light sources in HDR games, such as a shaft of sunlight in *Cyberpunk 2077*, positively sizzle. In terms of absolute peak brightness, it's got more game than the Alienware OLED monitor. As for speed, the Neo G9 is very good for an LCD panel. But without wanting to give too much away, it simply isn't in the same zip code as OLED for pixel response.

So, which would I choose? That's a tough question. For fundamentals like lighting, contrast, and viewing angles, a per-pixel emissive technology like OLED is simply superior. It's faster than LCD, too. On the other hand, LCD tech is now incredibly good at compensating for its inherent disadvantages. And the sheer size and immersion provided by the Neo G9 make it very special indeed.

For me, the answer is that I don't want either of them on account of both suffering pretty poor pixel density of below 110DPI. My daily driver is a 32-inch 4K panel with 140ppi and that's barely enough to satiate my demand for sharp fonts and crispy image detail. But if I had to choose between the Samsung Neo G9 and the Alienware AW3423DW, it would be the G9 warts and all. In the end, size does matter. And 34 inches doesn't do it for me. **–JL**

$1,999, www.samsung.com

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MSI GeForce RTX 3080 12GB Suprim X

RTX 3080 Ti Redux

WITH GRAPHICS CARD shortages still plaguing the world, the fine folks at Nvidia thought what we needed was another extreme GPU priced over $1,000. Shakespeare might opine that a GPU rose by any other name would perform just as fast—or, alternatively, a 3080 Ti by a different name would cost as much.

You can easily imagine the wheels churning behind the scenes. When every GPU produced gets sold immediately, typically at massively inflated prices, why bother with lower-priced models? The RTX 3080 10GB that launched in September 2020 supposedly starts at $700, though it still routinely sells for $1,300 or more. Meanwhile, the RTX 3080 Ti starts at $1,200, but online goes for closer to $1,700. If Nvidia is getting a fair number of GA102 chips that have all 12 memory channels fully functional, but can't meet the 80 SMs (streaming multiprocessors) requirement of the 3080 Ti, why not create an in-between SKU, such as the 3080 12GB?

Nvidia claims the impetus behind the RTX 3080 12GB came from its add-in card (AIC) partners, so there's no reference 3080 12GB, only custom cards such as the MSI RTX 3080 12GB Suprim X we're using for this review. And it's quite the specimen, sporting a triple-fan, triple-slot design and tipping the scales at 1.9kg—not the heaviest graphics card we've ever seen, but no lightweight.

The baseline specs for the 3080 12GB consist of the same 1710MHz boost clock, with 70 SMs instead of the 68 on the 10GB model, but MSI cranks the boost clock up to 1845MHz for the Suprim X. The 3080 Ti has 80 SMs and a 1665MHz boost clock, with the same 12GB of GDDR6X 19Gbps memory. The net result is that MSI's 3080 12GB card has theoretical compute performance that's only three percent lower than the 3080 Ti. Due to the higher clocks, which affect texture and ROPs throughput among other things, the Suprim X even outperforms the 3080 Ti Founders Edition at times.

You can easily get around that by comparing the MSI card to custom 3080 Ti cards with a similar factory overclock, like MSI's 3080 Ti Suprim X. Regardless, the RTX 3090, 3080 Ti, and 3080 12GB all generally perform within a narrow five percent range due to power limits from the GDDR6X memory and the GPU core. The 400W power limit of the MSI card helps it to achieve and maintain higher clocks on average, and we typically saw GPU clocks of around 1.95GHz, 100MHz higher than the rated boost clock.

MSI's large cooler proves effective in dissipating the generated heat, with GPU core temperatures topping out at about 71°C. The noise levels were still good, hitting 48.8dB(A) at 10cm, and in a typical enclosed case, the GPU created less noise than the CPU and case fans. More importantly, the GDDR6X temperatures were also reasonable, staying below 100°C regardless of workload—including some cryptocurrency mining tests (not that you'd want the card for mining, as Nvidia's LHR limiter is in full effect).

This performance on tap does come with a cost, naturally, and MSI's $1,249 MSRP sits firmly in 3080 Ti territory. The reality is you're still getting 12.5 percent fewer SMs and GPU cores. Street prices put the 3080 12GB cards about $200 lower than the 3080 Ti, however, so if you don't need the extra cores and plan to run at factory clocks, you're not giving up more than a few percent in performance.

But there's a skunk lurking in the rose bush. Like all extreme GPUs, the supply of the RTX 3080 12GB cards remains limited, unless you're willing to pay a premium. With Nvidia's Ada architecture and the presumed RTX 40-series less than six months away, if you're not already on the Ampere bandwagon, it's probably best to just give it a pass. **–JARRED WALTON**

BENCHMARKS

	RTX 3080 12GB	RTX 3080 Ti	RX 6900 XT	RTX 3080 10GB
10 Game Average (fps)	**97 / 60**	**97 / 60**	96 / 57	89 / 55
Borderlands 3 (fps)	114 / 66	118 / 68	**131 / 70**	105 / 60
Control (DXR)	66 / 33	**69 / 34**	47 / 22	62 / 30
Cyberpunk 2077 (DXR)	43 / **21**	**44 / 21**	25 / 11	39 / 19
Far Cry 6 (fps)	131 / 83	130 / 82	**141 / 86**	122 / 75
Flight Simulator (fps)	79 / 53	**80 / 54**	**80** / 51	78 / 46
Forza Horizon 5 (fps)	111 / 82	107 / 80	**130 / 91**	101 / 76
Horizon Zero Dawn (fps)	150 / 88	150 / **89**	**160** / 85	132 / 80
Minecraft (DXR)	61 / 29	**62 / 31**	31 / 15	56 / 27
Red Dead Redemption 2 (fps)	**117 / 81**	116 / **81**	113 / 77	106 / 75
Watch Dogs Legion (fps)	**100 / 63**	98 / **63**	98 / 58	90 / 56

Best scores are in bold. All testing conducted with a Core i9-12900K, MSI Pro Z690-A WiFi DDR4, 2x16GB DDR4-3600 CL16, 2TB Crucial P5 Plus M.2 SSD, Cooler Master MWE 1250 Gold V2. Scores are average framerates at 2560x1440 / 3840x2160 ultra, with ray tracing enabled in Control, Cyberpunk, and Minecraft.

VERDICT
7

MSI GeForce RTX 3080 12GB Suprim X

➕ **ROSES** Excellent performance; potent cooling; hefty overclock.

➖ **SKUNKS** Power hungry; basically a 3080 Ti; Ada is coming.

$1,249, https://www.msi.com/

SPECIFICATIONS

Architecture	GA102
Lithography	Samsung 8N
Boost Clock	1,845MHz
GPU Cores	8,960
Memory	12GB GDDR6X
TFLOPS FP32	33.1
Bandwidth	912 GBps
TDP	400W
Connectors	1x HDMI 2.1, 3x DisplayPort 1.4

GEFORCE RTX

MSI's Suprim X cards are massive, providing copious cooling in a triple-slot form, with plenty of RGB lighting too.

At 14.6-inches, this is the biggest tablet available anywhere.

Samsung Galaxy Tab S8 Ultra

Samsung's Android tablet goes Ultra big and Ultra thin

THE ONLY ANDROID tablet to really take on Apple's iPad Pro at the premium end of the market so far is the $850 Samsung Galaxy Tab S7+, released back in August 2020. It turns out that wasn't premium enough for the Korean manufacturer, so now we have the Galaxy Tab S8 Ultra. The "U-word" has been rolled out for the first time to denote, as on the Galaxy phone line, that this is the very best in the range.

So what makes this $1,099 tablet so Ultra, given that the S8+ also still exists for $899? It's all about the screen—a ridiculous 14.6-inch OLED 120Hz display that's nearly as big as most 15-inch laptop panels. The Ultra model also boasts the thinnest body ever on a Samsung tablet at just 5.5mm, as well as dual front-facing cameras that work well for video calls, but are housed in an Apple-like notch that intrudes on the display.

The size of the Tab S8 Ultra is both its greatest strength and its biggest weakness. This is an incredible display—not quite as bright as the most recent iPad Pros, but bursting with color and detail that make media consumption a joy. This is a tablet on which you can view magazines in landscape, such is the size and resolution of the display. It also makes the tablet a superb multi-tasker, as you can run three or four apps at the same time without compromise.

That said, holding the tablet in landscape is pretty much a necessity, as the height of the device in portrait makes it uncomfortable to hold for long periods of time. It's not heavy, nor is it thick or difficult to hold, but the weight distribution feels a little off. Some people will be able to overlook this, given the benefits of a laptop-sized display in tablet form, but the screen is a couple of inches too big. To paraphrase *Jurassic Park*'s Ian Malcolm, Samsung's scientists were so preoccupied with whether they could, they didn't stop to think if they should.

As a result, getting a stand is a must. Samsung's own Ultra Book Cover Keyboard costs a ridiculous $350—at that extra price, most people would be better off buying a laptop. The official Protective Standing Cover represents much better value at $70 and, while it's not as slick a solution, you can then pair it with any Bluetooth keyboard or mouse.

Either of those setups will allow you to enable Samsung's DeX mode, which turns the tablet into a basic Android-powered laptop. It's best to think of DeX as an emergency or backup computer rather than a full-on laptop replacement. It allows you to browse the web and perform basic productivity tasks but is still some way short of Windows and Mac OS when it comes to app support, speed, and general ease of use. That said, DeX is a great bonus feature, which is sorely lacking from Apple's tablet offerings.

Another thing Samsung does better than Apple is the inclusion of the excellent S Pen stylus in the box. This is to be applauded, as it's both fluid and highly functional for sketching and note-taking. The charging on the rear of the device feels cumbersome and the pen is prone to detaching easily, but it can also be magnetically attached to the frame when not charging. The lack of a charger is a painful omission, however—we get that manufacturers are trying to help the environment, but charging the massive 11200mAh battery without Samsung's 45W fast charger takes hours.

The biggest criticism of the Tab S7+, and indeed all Android tablets, remains though—Google's OS just isn't cut out for tablets in the same way as Apple iPadOS. For its part, Samsung is doing everything possible to change that. The new dual front-facing cameras include an ultrawide module for group calling, there's a feature to force apps to use landscape mode, and the video-editing app LumaFusion will soon be making its debut in the Samsung App Store.

The Samsung Galaxy Tab S8 Ultra is an enormously impressive tablet. While it makes a fantastic first impression with its gorgeous screen and thin body, we found longer-term concerns about general comfort when used as a tablet and the cost of its accessories. If you want the best Android tablet going though, there's no question this is it. **–GUY COCKER**

VERDICT
7

Samsung Galaxy Tab S8 Ultra

+ **ULTRA BRILLIANT** Gorgeous screen; incredibly thin; great for multitasking.

− **ULTRA LAME** Expensive keyboard case; no fast charger included; no headphone jack; has camera notch.

$1,099, samsung.com

SPECIFICATIONS

CPU	Qualcomm Snapdragon 8 Gen 1 Octa-Core Processor
GPU	Adreno 730
Display	14.6-inch, 2980 x 1848 pixel, Super AMOLED, 120Hz, 240ppi
Cameras	13MP + 6MP (Rear), 12MP + 12MP (Front)
Memory	8GB RAM/128GB ROM (tested), 12GB RAM/256GB ROM, 16GB RAM/512GB ROM
Card Support	Up to 1TB microSD, SIM Card (5G models only)
Battery	11200mAh
Charging	Up to 45W (not included)
Dimensions	326.4 x 208.6 x 5.5mm
Weight	728g

Steam Deck

Valve's Steam Deck is here, but how does it stack up?

THE FIRST THING you should know about Valve's Steam Deck is that despite its looks, this isn't a Nintendo Switch alternative. It's so much more than that. Sure, it looks like a handheld console, but Valve has made an impressively open and powerful device that's actually more like a gaming laptop alternative. In that respect alone, it's a triumph.

For PC gamers with a Steam library, the Steam Deck gives you a ready-made collection of games—open up the Steam Deck, log in, and all your games will be waiting. Not every game is compatible with the Steam Deck, mainly because it runs Steam OS 3.0, a Linux-based distro, and relies on Proton, a software compatibility layer that allows Windows games to play on Linux. When it works, it works incredibly well, and there's no noticeable performance impact. But, due to the sheer size of the Steam library, some games will either have compatibility issues or won't run at all.

While those are thankfully pretty rare, it does mean that you'll need to check that your favorite games are supported. Valve has rated each title as 'Verified', 'Playable', 'Untested', or 'Unsupported'. Any Verified or Playable game, and most Untested titles, will play fine, and we tested a huge range of games, from 2D platformers and indie games to graphically-demanding games such as *God of War* and *Elden Ring*. Valve has packed an impressive amount of power in the Steam Deck, and the 800p 7-inch screen means that it punches above its weight. Seeing *God of War* playing on this handheld is seriously impressive and blows away the Switch.

As Valve reiterates, the Steam Deck is a PC, so while the new-look Steam Big Picture Mode is the main interface, you can switch to desktop mode and install additional programs, games, and applications. You can also install other Linux distros, or even other operating systems like Windows 10. This brings a level of flexibility that locked-down game consoles don't have. Design-wise, the Steam Deck looks like the lovechild of the Nintendo Switch and the Sega Game Gear. It's chunky, but feels comfortable when held, and comes with a huge amount of buttons, along with two thumbsticks and two trackpads. Between them, the buttons and a D-Pad, you can control most games relatively easily, even if they usually rely on keyboard and mouse.

There's also a USB-C port for charging the Steam Deck, which also allows the handheld to be plugged into a USB-C dock. An official dock is coming soon, but it also works with third-party docks. Unlike the Switch when it's in Docked mode, there are no additional performance benefits, but you can plug in peripherals, TVs, and storage. There's also a microSD card slot for adding more storage, though speeds are limited. Battery life is poor, lasting just an hour and a half playing *God of War*. A few tweaks, such as locking the handheld to 30fps, can prolong the battery, as can playing more basic games.

The Steam Deck comes in three versions; a $399 model with 64GB eMMC storage, a $529 model with 256GB NVMe SSD, and a $649 version with an NVMe SSD internal storage and premium anti-glare etched glass. If the Steam Deck takes your fancy—and it really should—we'd recommend the 256GB or 512GB models, as 64GB of slower storage will just leave you frustrated. **–MATT HANSON**

VERDICT
9

Valve Steam Deck

POSITIVELY STEAMED Good performance; huge library.

NEGATIVE SOGGY Poor battery life; slow SD card speeds.

$399-649, https://store.steampowered.com

SPECIFICATIONS

CPU	AMD Zen 2 four core 2.4-3.5GHz
Graphics	AMD RDNA 2
RAM	16GB LPDDR5
Screen	7-inch, 1,280x800 touchscreen, 60Hz
Storage	64GB eMMC/256GB PCIe SSD/512GB PCIe SSD
Ports	USB-C, microSD, 3.5mm headphone jack
Connectivity	Wi-Fi 5, Bluetooth 5
Weight	1.47lbs (0.67kg)
Size	1.9 x 11.73 x 4.6-inches (hwd) (4.9 x 29.8 x 11.7cm)

GPU 99% 78°C
7068
CPU 46% 79°C
VRAM 1.0
RAM 5.1
BATT 15% 25.5
GAMESCOPE 30 FPS 33.5
5:51 AM / CLEAR
NEARBY
LILAC AND GOOSEBERRIES
Follow Vesemir.
Y
X
B
A

The Steam Deck isn't the smallest handheld, but it's not uncomfortable.

Dell Ultrasharp U3223QE

Is this the sharpest tool in the box?

MAYBE WE NEED to get out more, but there was genuine excitement when the new Dell Ultrasharp U3223QE, a sober-suited 32-inch monitor designed primarily for productivity, landed at *Maximum PC*. The U3223QE has limited HDR support, no local dimming, runs at a mere 60Hz, doesn't have quantum dots or lots of tiny LED backlights. It isn't even curved.

So what's the big deal? Dell claims it is the first use of 'IPS Black' technology from LG, the first company to mass-produce IPS panels. IPS Black improves the contrast performance of IPS panels to fully 2,000:1. That's a big boost over the best existing IPS screens, which are good for 1,300:1 and have been stuck at that level for nearly a decade. Many current IPS screens only manage 1,000:1.

Of course, these figures refer to the static contrast achieved by the LCD panel itself. In other words, not contrast performance enabled by a backlight or local dimming. In many ways, improving static contrast is preferable to fancy backlight technology. It is less complex and costly to have good inherent contrast than mess around with complicated tech. Even now, few monitors have true full-array local dimming, and those that do cost megabucks. So, a big improvement in static contrast will benefit monitors at a wide range of price points.

The Ultrasharp U3223QE has a strong productivity feature set. It's a 4K panel with slick slim-bezel styling, lots of desktop real estate, USB-C connectivity with 90W power delivery, monitor daisy-chaining and ethernet passthrough, plus a KVM switch. You also get excellent color fidelity with 98 percent coverage of the demanding DCI-P3 digital cinema space. OK, this isn't a true pro-level panel for image and video editing. But that kind of color coverage is certainly enough for most content creation workflows.

On paper, it's the step in contrast performance that sets this panel apart. In practice, it's far less impressive. In subjective terms, the U3223QE is little better in terms of contrast, vibrancy, and black levels than a monitor based on a good existing IPS panel. That isn't entirely surprising. VA panel tech is capable of 3,000 to 4,000:1 static contrast. And while that advantage is noticeable in comparison with an IPS monitor, it's not night-and-day.

It also doesn't help that the U3223QE's factory calibration is tilted towards green. This supposedly cutting-edge new IPS panel doesn't produce the cleanest or purest of white tones, either. There's a little compression evident in some test images. In fact, compared with another, less advanced, 32-inch 4K monitor, we prefer the older 1,300:1 panel. For the record, pixel response in the Dell's standard mode is adequate given the productivity rather than gaming remit. Achieving the claimed 5ms performance, however, requires enabling overdrive in the OSD menu, and with that comes some ugly overshoot and inverse ghosting.

All of which makes the Dell Ultrasharp U3223QE a little disappointing. Contrast performance is IPS's most obvious weakness. On this viewing, IPS Black doesn't do as much as we'd hope to address that. This remains a nice screen with all the usual benefits of a quality 4K monitor, including nice, crisp fonts and oodles of desktop elbow room. The comprehensive productivity and connectivity feature set is also excellent but none of those things are unique to the U3223QE. The bit that is, the IPS Black panel, doesn't do it for us. **–JEREMY LAIRD**

VERDICT
7

Dell Ultrasharp U3223QE

⊞ **LIFT OFF** Epic productivity feature set; usual 4K thrills.

⊟ **SPLASH DOWN** IPS Black tech is a bit of a let down.

$919, www.dell.com

SPECIFICATIONS

Panel size	32-inch
Panel type	IPS
Resolution	3,840 x 2,160
Brightness	400cd/m2
Contrast	2,000:1
Pixel response	5ms
Color coverage	98% DCI-P3
Refresh rate	60Hz
Vesa	100mm x 100mm
Inputs	DisplayPort 1.4, HDMI 2.0, USB-C with 90W PD
Other	DisplayPort out, ethernet, HDR400

The U3223QE is the first monitor to use LG's new high-contrast IPS Black technology.

Netgear Orbi AXE11000 Mesh WiFi System

Quad Band for luxury home networking

WHEN THE FIRST NETGEAR Orbi arrived in 2016, mesh Wi-Fi systems were largely the domain of offices managed by IT professionals. But as homes started to absorb more smart devices and faster internet, they began to be released in kits sold by the likes of Amazon. Six years on, gigabit internet-enabled homes and WiFi 6 devices are becoming the norm.

Netgear has responded with the Orbi AXE11000, which is on the cutting-edge of networking standards. Top of the spec sheet is WiFi 6E support for devices with a theoretical maximum 4800Mbps throughput. Wired networking is equally fancy, each node boasting a 2.5G ethernet port, with a 10G internet port on the router.

The catch is the $1,499 price tag. If you have lots of WiFi 6E devices, a computer or server with a 2.5G ethernet port, and spend a lot of time on your home network, maybe you can justify it, but there are WiFi 6 systems, such as Netgear's AX6000, that will save you at least $500.

For testing, we used the Netgear AXE11000 to replace an aging Linksys Velop WHW0303 5GHz system, dotting the nodes around the home to serve 29 Wi-Fi-enabled devices. Each of the Orbi nodes is much larger than the Velop, but they're stylish and boast more network ports. Setup is easy, just plug the main node into your existing router, scan the QR code using the app, and the system configures itself, downloads updates, and tells you how and where to add satellites.

You can quit the Orbi app and never use it again after this stage, but it soon starts to become annoying. Go into Security and press the innocuous-looking "Armor" button, and you'll start a 30-day trial for Netgear's Security suite, costing $100 per year. Open the app again, and you might be prompted to set up parental controls, which costs another $70 annual fee. Both are useful features, but having spent $1,500 on a top-of-the-line system, being asked to pay even more seems unfair.

Apart from that, the Orbi features are rather basic. There's a traffic meter to keep track of data usage, a separate IOT network for older smart home devices, and an analytics tool to detect Wi-Fi channels with the least congestion. You can also link it with Google and Amazon smart assistants if you want to open up a guest network, for instance.

But in terms of wireless coverage and speed, the system excels. Just three nodes covered our home. For the speed test, we plugged a Synology DS918+ NAS into the main hub and a desktop PC into a satellite across the house. Using LAN Speed Test to monitor the read speed of a 1GB file, the speed went from 130.57Mbps on the Velop to 225.58Mbps on the Orbi, a 73 percent increase. Whether that is worth the premium is your choice, but it's a decent boost for anyone shifting a lot of data around their home.

The Netgear Orbi AXE11000 will be too expensive for all but the most ardent of home network users, and even they may wish to choose a cheaper WiFi 6 system. But if all you want is the fastest networking system going, then you'll get what you came for here. **–GUY COCKER**

VERDICT
7

Netgear Orbi AXE11000

+ WI-FI Super-fast wired and wireless networking; stylish design; simple setup.

– LO-FI Security and Parental features cost extra; large physical footprint; no QoS features.

$1,499, netgear.com

SPECIFICATIONS

Wireless	1200 + 2400 + 2400 + 4800Mbps, 2.4GHz, 5GHz & 6GHz
Security	WPA3
CPU	Quad-Core 2.2GHz processor
RAM	1GB
Storage	512MB NAND Flash
Ports	1 x 2.5Gbps, 3 x 1000Mbps Ethernet LAN ports per Satellite, 1 x 10Gbps Ethernet WAN port (Router Only)
Smart Assistant Compatibility	Amazon Alexa and Google Assistant
Dimensions	11 x 7.5 x 3.3in (per node)
Weight	3.0lb (per node)

The access points are stylish and offer great coverage.

XGIMI
HOME SMART PROJECTOR
XGIMI Projection Lens
Throw Ratio 1.2 1080p
harman kardon
AUTO
KEYSTONE

The XGIMI Halo+ is a practical and portable option

XGIMI Halo+ Projector

The all-in-one home-theater companion?

IF YOU'RE THINKING ABOUT switching up your living room rig or want to move away from a traditional display, choosing a projector is certainly one way to do it. It isn't the easiest transition to make—projectors don't generally offer the same high-quality image that you'd expect from a 4K monitor or TV set but, slowly and surely, the quality is improving.

Of course, the projector has a few other factors to contend with, such as the need to block out sunlight and the practicality of mounting a projector to a ceiling, but a range of powerful and altogether more portable devices have entered the market that could make owning a projector a viable option. One such device is the XGIMI Halo+. Does it achieve its goal, or is this projection inaccurate?

The most obvious feature of the Halo+ is its size. This box-like device is far smaller than a conventional projector, making it a more convenient piece of tech to have in your home. When creating an area to use a projector in, you want as little clutter as possible to make the experience more immersive and, by shrinking the form factor down, XGIMI has achieved this. It's small enough to sit on a shelf at the back of the room and portable enough to offer flexibility in terms of its placement. The base features a tripod mount and a tiny kickstand that raises the front of the projector and also helps stabilize it.

As far as design goes, it's a stylish product, with a satin effect grille pattern covering the majority of the body. If you didn't know what you were looking at, you could easily mistake this for a high-end portable speaker. This is presumably deliberate, as the XGIMI features sound by Harman Kardon and Dolby Audio, which is a pretty good combo. It goes loud enough to fill a decent-sized room and is perfect for when you take it out on the go. You will likely keep this in a fixed position, but the option is there and it's a positive for the XGIMI Halo+.

If you're taking this on a camping trip or just moving it to another room, it has up to two hours of battery life, just enough for the average movie or a couple of episodes of a TV show. We'd love it if you could squeeze another couple of hours out of the battery, but that would undoubtedly come at the cost of portability, and we think XGIMI got the balance right here.

PORT OPTIONS

This projector features a few ports on the back, including HDMI 2.0, USB 2.0, and a 3.5mm jack. For most uses, this is enough, although having that safety net of more ports would be nice. However, this projector has Android TV built-in, so is ready to get streaming straight out of the box. With plenty of applications to choose from and an easy-to-use UI, it works well as a smart TV replacement. Google Assistant and Google Chromecast are packed into this little device too, which increases its accessibility even further.

We found there was currently an issue with the native Netflix app, which is a shame. To get around it, we connected an external Chromecast via HDMI, and kept it powered using the USB port on the Halo+. Regardless of this, the projector is controlled through the remote control that comes in the box. It's small, sleek, and easy to use, which is all you'd want from a remote. There's a setting button at hand and a focus slider on the bottom, so if the projector goes out of focus, it's easily adjustable in seconds.

So, with many of the boxes already ticked, how does it perform? We recently tested the Asus H1 projector ($1,099) and quality-wise, that gets our vote between the two. However, these aren't in the same category. The Asus offering is a more permanent device with no operating system or stand-out features and has poor built-in speakers. It's also a lot brighter than the Halo+'s 900 lumens, but the XGIMI still offers a vibrant image.

The Halo+ has a great auto-keystone feature, which means you don't have to have the projector straight-on to your surface or projector screen, as it will adjust automatically. You can tweak it manually too, making setup a breeze.

However, this small projector doesn't come cheap, with a price just shy of $850. But for that, you get a great all-around package in the XGIMI Halo+, a crisp and bold display, a decent speaker, portability, Android TV, and ease of use.

There's something about using a projector that makes watching a film just that extra bit special and a TV can't recreate that feel. It's an enjoyable device to use rather than a hindrance to your viewing experience. There are just a few minor gripes, including the battery life, that hold it back. **–SAM LEWIS**

VERDICT

9

XGIMI Halo+

+ **BIG SCREEN** High-end design; solid sound; portable; clear display; Android TV built-in and auto keystone.

− **SMALL SCREEN** 60Hz max refresh rate; lack of ports; poor battery life.

$849, us.xgimi.com

SPECIFICATIONS

Projector type	DLP
Native Resolution	FHD 1920 x 1080
Refresh rate	60Hz
Brightness	900 lumens
Projection Size	Up to 200-inches
Connectivity	WiFi Dual-band 2.4/5GHz, Bluetooth 5.0
Ports	HDMI 2.0, USB 2.0 Type-A, RJ45, 3.5mm aux, DC in
Weight	3.5lbs
Size	4.46 x 5.70 x 6.75-inches

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Elgato Stream Deck MK.2

Your PC's best pal or annoying neighbor?

HAVING BEEN AROUND since 2017, Elgato's quirky little macro switches have made a name for themselves in the creative, live streaming, and gaming circles. If you like keeping your desktop setup neat and tidy, the idea of adding another peripheral may not be appealing. However, this one is designed primarily to streamline your work and to make your PC experience as efficient as possible. So, should you add a Stream Deck to your desk or stick to the old school mouse and keyboard method?

There are several variants in Elgato's Stream Deck lineup. There is the original model, the XL version, the Mini, the mobile app, and the pedal accessory. The one we have on test here, the MK.2, is a revamp of the original version. It now features 15 physical LCD macro keys and comes in a white variant. What it gives you over the original model is a nicer 45° detachable kickstand, interchangeable faceplates for more customization, and a removable USB-C cable.

The Stream Deck MK.2 is a fresh-looking peripheral that sits discreetly on your desktop. The detachable kickstand looks much cleaner than the MK.1, although the old one had different levels of adjustment. The clarity of the LCD screens isn't revolutionary, but they clearly display the keys' icons.

The Stream Deck has 15 customizable action buttons that allow you to complete a variety of different tasks. These are all chosen and customized within Elgato's Stream Deck app, which is where all the magic happens. Opening it up reveals a simulated version of your Stream Deck on screen. Although there are only 15 physical keys on the device, here you can create an infinite amount of keys and actions—more than you'll ever need.

You can add additional pages to your Deck, which adds a 'next page' button to the bottom corners of your device. Each new page gives you even more blank keys to play with. You can also create folders within these pages and to take things even further, you can create folders within folders, much like File Explorer. And as if that wasn't enough, you can set up different profiles on the Stream Deck, which is handy if you want a setup for streaming and one for gaming, or if you have multiple users on a specific PC.

So there are tons of possibilities and more than enough real estate space within the Stream Deck. This makes the larger XL model a bit of a harder sell, but we prefer this version over the Mini as 15 keys is a good middle ground in our opinion. So, what sort of actions can you create within the app?

IN CONTROL

The right side of the interface features all of the functions which you then drag and drop onto the virtual Stream Deck interface. Some of these functions include Elgato game capture shortcuts, such as scene, record, screenshot, stream, and others. You get similar controls with OBS Studio, Twitch, and Streamlabs options too.

The more generic controls are found in the system and Stream Deck menus, where you can set a key to open a specific application or a website. You can create hotkeys that are perfect for creative tools such as Photoshop, change the brightness, add multi-media controls to adjust the playback of your PC, and more.

During testing, we set up one page to open specific Google programs, one for PC functionality, and another for gaming and streaming. For more customizing options, we changed the icons too—you can add anything you like as long as it's 72x72px resolution. You can also download tools, icon packs, and sounds from the Stream Deck store to make the device even more productive—anything from a Spotify plug-in to *Minecraft* stats.

Of course, the Stream Deck MK.2 doesn't give you anything that you wouldn't already have access to. What it does, though, is make performing that action so much easier with a simple press of a button, bringing speed and efficiency to your workspace. Whether you're streaming, being productive, gaming, or simply procrastinating, it's a handy device. The only question remaining is whether it is worth handing over some of your desktop real estate to this device.

When considering whether to purchase the Elgato Stream Deck MK.2, you may ask yourself whether you'll actually use it. The thought had crossed our minds too but, after giving it a try, we're hooked. Maintaining a minimal desk setup is difficult, but if you want to improve your rig, you should make room for this little tool. **–SAM LEWIS**

VERDICT
9

Elgato Stream Deck MK.2

+ **STREAMING** Endless functionality; bright keys; grippy base; big app store; clear and easy application.

− **FLOUNDERING** Bit pricey; only one level of angle adjustment.

$150, www.elgato.com

SPECIFICATIONS

Keys	15 customizable LCD keys
Connection	USB-C
Dimension	4.6 x 3.3 x 1.0-inches (without stand)
Weight	0.59lbs

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SCUF Instinct Pro

Precision shooting or complete overkill?

HOWEVER IMPRESSIVE your setup may be, it can easily be hindered by your choice of peripherals. Whether that's a controller or a mouse and keyboard combo, to get the most seamless gaming experience from your rig you need accessories to match. If you're considering going down the controller route, you'll probably have come across SCUF and the Instinct Pro, its latest controller for the PC and Xbox. The Instinct Pro sits at the top of its lineup alongside its PlayStation counterparts, so is it worth upgrading to a pro controller from the standard Xbox model, and how does it fare against the Xbox Elite Series 2?

At a glance, it looks like a typical Xbox controller, though our review sample features a rather neat custom dragon faceplate or, as SCUF calls it, Prosperity. Regardless of the design, the overall shape and configuration closely resemble the original Xbox controller, which is a plus. The satin finish on the faceplate and matching red primary buttons and RT/LT triggers work well with the aesthetic. The Instinct Pro has a nice weight to it but, apart from the rubberized grip on the handles, it's not too different from Xbox's regular controller—and it doesn't deliver the significantly more premium feel that you would expect for the price.

There are plenty of options for customizing your Instinct Pro, especially with the Prosperity faceplate. This is easy to change and you won't even need any tools—the plate is magnetized so you can pop it off without much of a struggle. Doing this reveals the bare buttons, a magnetized D-pad, and the controller's thumbsticks. In the box, you also get two extra domed thumbsticks, one of which is raised for FPS titles, and a braided 2m long USB-C cable.

Turn the Instinct Pro around and you will find those extra goodies that make this a pro controller. Our favorite feature has to be the trigger stop switches. These aren't available on the non-pro version and, in our opinion, are well worth the upgrade. Underneath each trigger is a little slider that switches the mode from a typical trigger with travel to more of a mouse-like click. Of course, with less travel, the input delay is reduced, resulting in a faster response time. This will be useful in FPS titles to shoot and aim as quickly as possible.

CAN YOU HANDLE IT?

On each handle, you also get two remappable paddles, which make a huge difference in online gaming. In competitive gaming environments, every millisecond counts and the faster you can react and input, the quicker you'll be. Having these paddles on the back gives fingers an input that on other controllers is just used for grip.

The Instinct Pro has three profiles—blue for FPS/battle royale, red for sports, and green for racing. Each paddle is assigned to one of the front buttons by default in each of these modes. To create your configuration, you press the configuration button on the back of the controller until you're on the profile you want to change. Then, you hold this button down until the light indicator starts to blink. Once it's blinking, you can press a paddle and then press another button on the controller simultaneously to remap it to that button. Press the configuration button once more to save this map.

This on-the-fly remapping gives the Instinct Pro even more options for customization and can improve your gaming experience by allowing you to play to your liking. Unfortunately, the controller doesn't have accompanying software or an app, so it is necessary to do it directly on the controller.

As a controller, it feels great in the hand, as the remappable buttons on the back have been ergonomically designed and the ability to switch the trigger style is a handy feature. It plays superbly too, giving you an advantage over users of standard controllers. The transition to using extra buttons can take a while to feel natural, but soon becomes second nature. Once tuned in, you'll notice snappier inputs that can make a big difference to your playing style.

There are a few issues that we can't ignore though. Firstly, there's the price tag—$210 is a lot to spend on a controller and it doesn't feel premium enough to warrant that price. It's also powered by AA batteries, which isn't ideal. Although it does a great job as a pro controller, the Xbox Elite Series 2 controller offers a similar experience at a lower price and that, unfortunately, makes the SCUF a less viable option. **–SAM LEWIS**

VERDICT 7

SCUF Instinct Pro

+ INSTINCTIVE NATURE Ergonomic remappable paddles; strong rubberized grip; trigger stop switches; lots of customization.

− FORCED NATURE Pricey peripheral; AA batteries; not premium enough.

$210, www.scufgaming.com

SPECIFICATIONS

Compatibility	Windows 10+, Xbox Series X/S, Xbox One X/S, Mac Os Catalina+, IOS 10+, Android
Ports	USB C, Extension port, 3.5mm stereo headset jack.
Power	AA batteries
Connectivity	Wireless Bluetooth, USB C
Weight	0.6lbs
Size	6.61 x 4.25 x 2.08 inches

techradar.pro

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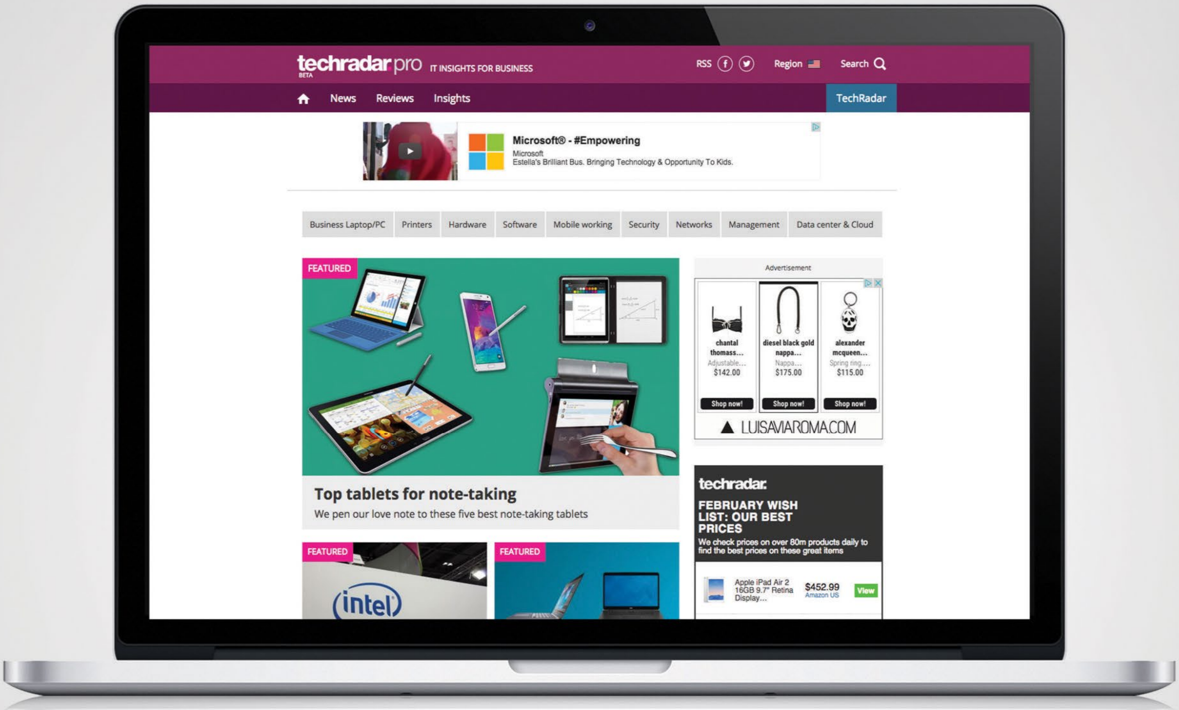
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NZXT H1 2022

Setting standards for ITX builds?

FOR A WHILE NOW, NZXT has made some tasty-looking cases that are more than just a bit of eye candy. The cable management, build quality, and overall feel of these chassis make them great value for money, while their relatively compact dimensions are good at keeping your desk setup crisp and clean. They usually provide a great blank canvas to work on, but the H1 design is arguably the best of an already good-looking bunch.

Unfortunately, the original H1 didn't get off to the best of starts after it was recalled after potential fire hazard concerns, which didn't exactly fill the market with confidence. Despite its impressive visual design, the Mini-ITX case came to its demise due to grounding issues on the PCIe riser cables.

Having got our hands on the improved V2 2022 edition, hopefully, those thermal issues have been resolved and the H1 2022 has a few extra goodies to add to the mix. Unlike the majority of NZXT cases, this one isn't a blank canvas—it comes pre-installed with an SFX 750W Gold PSU, NZXT CAM enabled fan controller, 140mm AIO liquid cooler, and room to support NVIDIA 30 series and AMD 6000 series graphics cards, which should make it an interesting Mini-ITX kit case.

Just like the V1, this revamped edition looks impressive, with more than a passing resemblance to the Xbox Series X console. With a 15.6-liter capacity, it's a little wider and taller to enable room for a full-sized two-slot GPU but keeps the same design as the original.

This small vertical case is so versatile that it should suit most setups. It's available in either matte black or matte white variants, the latter of which we have on test here. Three of the four sides of this case are designed with a circular pattern, providing up to 30 percent more ventilation than the previous model.

Airflow is a key upgrade this time with the introduction of the 92mm top exhaust fan. As heat rises, anything to help the flow of hot air escape this tight chassis is going to keep the PC cooler. The H1 also features a dual-chamber exhaust layout to keep both the CPU and GPU ventilated.

The panels are easy to pop off with no screwdrivers needed. The tinted glass and rear black panel detach from the top and bottom of the case and the other two sides slide off vertically, revealing the skeleton of the chassis. To help with your build, you'll find various stickers dotted around the case instructing you how to properly open the case, which is a handy and rather welcome addition, even for those who are more experienced at the building game.

Unscrew the radiator panel on the back of the case and it reveals where you can install a Mini-ITX mobo. It's simple and easy to do, making this case an ideal platform for any builders out there who are venturing into smaller form factors.

NO EMPTY PROMISES

So it's not an empty chassis and, with a 750W PSU and a power efficiency rating of 80 Plus Gold, it's capable of housing high-end, two-slot GPU's even larger units, such as Asus's ROG Strix cards, which is pretty impressive. The riser cable has also been upgraded from PCIe Gen3 to Gen4 to accommodate more current and powerful GPUs too. Sacrificing a powerful GPU on a Mini-ITX build isn't uncommon so it's great to see it being a viable option in this NZXT case.

Regardless of how impressive the airflow on this updated H1 case is, in general, smaller-sized cases can't compete with larger units that can dissipate the heat better. Nonetheless, the 140mm AIO liquid cooler in this mini machine does a good job of keeping the whole system cool.

Along with the large circumference holes in the panels, additional exhaust fan at the top of the case, and dual heat chambers, it's impressive what NZXT has crammed into such a small and sleek case. Now with PCIe 4.0 GPU support, it makes for a great Mini-ITX kit. Costing just under $400, you don't have to worry about the PC's cooling system and cabling solutions. Sure, it's not the cheapest kit on the market, but both the build quality and potential in this revamped H1 are seriously impressive. –SAM LEWIS

VERDICT
9

NZXT H1 2022

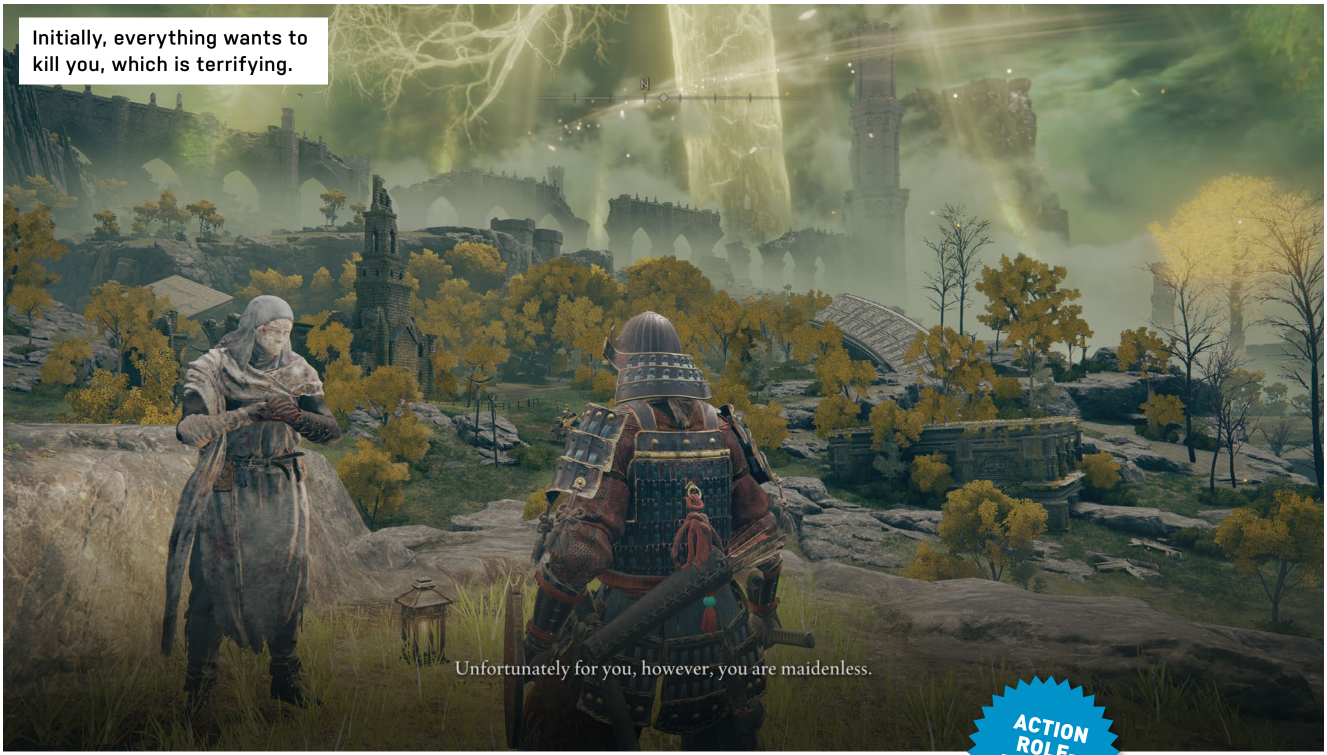
+ SECOND TIME LUCKY Good ventilation; clever use of space and cable management; compatible with full-sized GPUs; easy chassis to work on; safer PCIe riser cable.

− OOPS, WE DID IT AGAIN Can't use horizontally; hidden PSU switch; not compatible with three-slot GPUs.

$400, www.nzxt.com

SPECIFICATIONS

Form Factor	Mini-ITX
Motherboard Support	Mini-ITX
Colors Available	Matte Black, Matte White
Window Available	Yes
Front I/O ports	USB 3.2 Gen 1 Type-A x2, USB 3.2 Gen 2 Type-C, 3.5mm headset audio jack
3.5-inch Support	N/A
2.5-inch Support	2
Radiator Support	N/A
Fan Support	N/A
Dimensions	15.9 x 7.7 x 7.7-inches
Graphics Card Clearance	12.7-inches
CPU Tower Clearance	N/A
Weight	16.75lbs



Initially, everything wants to kill you, which is terrifying.

ACTION ROLE-PLAYING

Elden Ring

A game of souls and fire

LET'S GET THE elephant in the room out of the way first. *Elden Ring* is a Souls game. FromSoftware's string of action RPGs have a reputation for being brutally hard and unforgiving. From the original *Demon's Souls* in 2009, via the main *Dark Souls* trilogy and Eldritch spin-off *Bloodborne*, players have thrown themselves against the twin terrors of a game world designed to make them suffer, and gigantic bosses with matching health bars built to hammer home the point. Sometimes literally.

However, *Elden Ring* sees the Souls game, previously a *Metroidvania*-like dungeon-crawl that offered little sympathy to the underpowered character (or even those who found the controller a bit awkward to use) take a new approach. There's nothing as scandalous as an Easy mode, but the open-world setting does allow you to pick and choose who you fight and when, plus you can now run away more easily. Still, you move through this game in much the same way you did the others, pulling vague snippets of lore out of it as you give overpowered monsters a good thumping using nothing but your own skill and the tools you've been given.

There's a beautiful example of this just as you crawl out of the tutorial area and into the game world proper. A knight in fabulous armor on a golden horse patrols up and down. You can see him past the site of grace (save point) and the NPC who mumbles something vague to greet you. Depending on which character class you've chosen, you may be naked with a pot on your head, or you may be in full samurai armor with a katana. It doesn't matter. That knight is going to beat you into the grass over and over again.

You don't have to fight it. That's the lesson it's been placed there to teach. Far better to circle round, kill some animals, pick on a soldier or two that's closer to your level. *Elden Ring* isn't a Ubisoft game. There's no rash of objective markers, enemies don't telegraph their level with a number above their heads. You can't even pause the game without a mod or fishing around in menus. Eventually, you'll get a horse to make traversal faster and some boss fights easier, but initially, you don't know where you're going and everything wants to kill you—it's terrifying, especially for a newcomer.

And you're right to be terrified, because FromSoftware has been making games for a long time, and will use the assumptions you've built up from playing other games against you. Take the Twinblade. It's a really useful early-game sword for Strength-based characters, but you'd never know where to find it unless you Googled. It's just in a chest in an unmarked location. So the developers have placed another treasure chest nearby, which is a trap that teleports you to a cave full of tough enemies you can't fast travel out of.

ENORMOUS LANDS

The fast travel system is essential because the Lands Between, as the setting is portentously called, is enormous. It's as crammed with things to do as any *Assassin's Creed*, with something to fight, or a character to speak to, around every corner. Our favorites include the Pope Tortoise, or Miriel, Pastor of Vows; the smithing master with horns growing out of his skin, and the NPC who offers to hug you, nipping off a bit of your max HP as she does so.

Much has been made of the involvement of George R. R. Martin in the creation of the game's lore, but you'd be hard-pressed to find a trace of the occasional novelist beyond the four main antagonists' names beginning with G, R, R, and M. Martin's most famous world was a generic fantasy setting in which characters behaved

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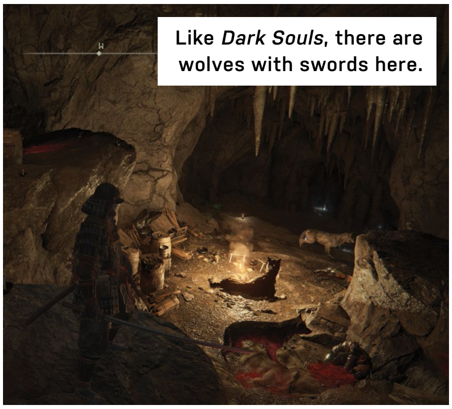
The knight on a golden horse is there to teach you a lesson.


Like *Dark Souls*, there are wolves with swords here.

Elden Ring's open world is a grand project elegantly resolved.

Don't fight everything! Pick on soldiers close to your level.

realistically, and therefore dreadfully, to one another, but here there's little sense of a society or a hierarchy at work. There are lots of soldiers, sure, even some foes who use frost powers, and a whole group called the Night's Cavalry. But it's hard to see a single mind behind the characters with multiple arms grafted to their bodies, spear-wielding skeletal birds, and a fire giant called 'Fire Giant'. Who came up with that one?

There's something else at work too, *Elden Ring* acts as a greatest hits compilation of moments that have gone before from the *Dark Souls* games. There's a wolf with a sword you may recognize, a poisoned swamp you might not want to get lost in, the sites of grace are very much like the bonfires of the past. It even reuses its own character models, palette-swapping them and mixing up moves.

All the while you're playing, especially at the start, you'll see ghosts flitting about. These, as long as your PC is connected to the internet and you haven't opted to play completely offline, are the shades of other players. What they're doing there isn't fully explained, but they're key to the game's multiplayer system. The first thing you notice are the notes left everywhere, messages from other players explaining what's ahead... or more likely trying to send you in the wrong direction or into the teeth of a ferocious boss.

DISTRACTING NOTES

Almost every creature in the game now has a player note in front of it calling it a dog. There are hints about breakable walls and secret areas where none exist. Thanks to the automatic censorship, you'll frequently find notes that read simply 'but hole'. Safe areas have notes warning of bosses ahead, holes have notes encouraging you to jump in. The real multiplayer is the summoning system, which allows you to call for help with bosses if you're getting overwhelmed, but the *Elden Ring* community, even in the first few days after launch when we were playing, has both a sense of humor and a liking for player suffering that mesh nicely with FromSoftware's.

Of course, it's not perfect. As we played, the amount of stuttering as textures were loaded into graphics memory was noticeable. A fix is promised, but there are deeper problems including a lack of accessibility options, few PC-specific graphics settings, UI quirks such as opening and closing the map screen using different buttons. Then there's the way being dropped into an open world full of hostiles with no idea where you're going beyond a vague story intro about a shattered ring makes you feel.

But persevere, and the game has plenty of great sights to show you. Not only is the open-world beautifully made, but its inhabitants are also full of grandeur and imagination—the way bosses draw their weapons is a particular highlight. *Elden Ring* has become beloved of games journalists and players for a reason, sparking hundreds of online pages of discourse, analysis, and opinion. It's a grand project elegantly resolved, and it's not often that we see many games of this quality. **–IAN EVENDEN**

VERDICT 9

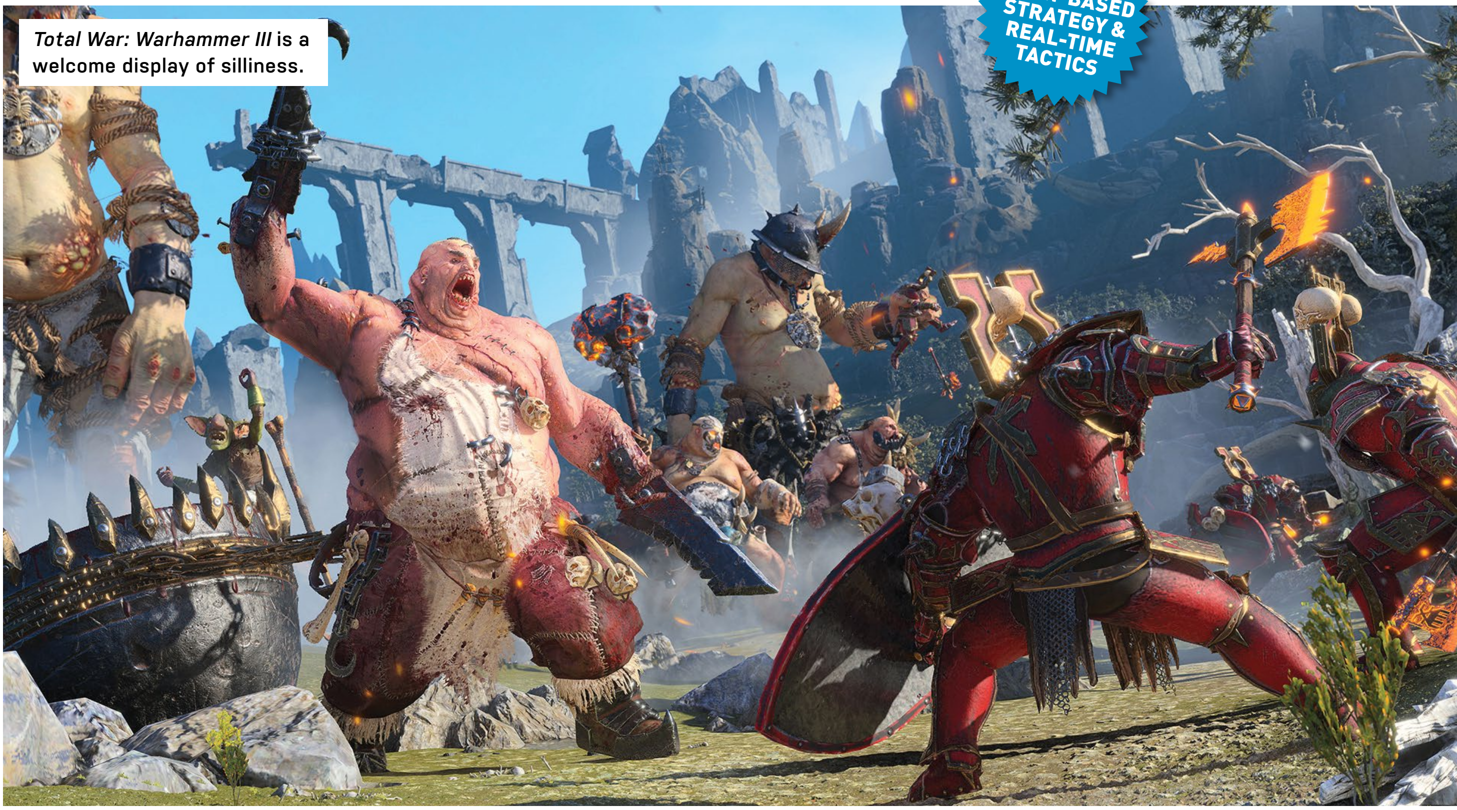
Elden Ring

BOSS FIGHT Gorgeous open world; lots of interesting things to fight and kill.

BOSS KEY A lack of direction; performance issues; can be very difficult.

RECOMMENDED SPECS CPU, i7 8700K / Ryzen 5 3600X. RAM, 16GB. GPU, GTX 1070 / RX Vega 56.

$60, eldenring.bn-ent.net/en, M-rated



Total War: Warhammer III is a welcome display of silliness.

Total War: WARHAMMER III

Cry havoc! And unleash the blue-tentacled dogs of war

WE TAKE THE WORSHIP of the dark gods seriously here at *Maximum PC*. When it's not the simple brute-force power exemplified by Khorne we're getting excited about, it's the serpentiform Slaaneshi curves of a liquid cooling system, or whatever Tzeentchian sorcery makes PCs work in the first place. Sorry, Nurgle, we haven't worked out a tortured metaphor for you, yet.

The injection of Warhammer's chaos gods into *Total War* for its third installment based on the tabletop war game is just the shake-up that the game we aren't supposed to call 'Total Warhammer' needs. While the second installment arrived bearing new races, the third wasn't going to get away so easily. A heavy dose of sorcery to join the swords makes the game feel fresh again.

So what's new? The barrier separating the worlds of men and demons has been torn apart and hellish forces are flooding the land. They come in four types: the armies of Nurgle, the god of plague and pestilence, all green fumes and huge fat units with gaping maws on their bellies; Khorne, the god of war, with his traditional horned and bat-winged demons complemented by mystical machine guns and metal war-rhinos. There's Slaanesh, the prince of pleasure, who favors androgyny, hooves, and seafood; while the god of sorcery, Tzeentch, has bird-like followers, flying disks, and multi-limbed creatures known only as 'Horrors'.

What do these fantastical, grotesque creatures bring to the massed battles we've come to expect from *Total War*? Well, they certainly add verticality. Not only are there flying creatures, but many of the walking, or lumbering, ones are enormous, towering over the battlefield and any swordsmen or archers unlucky enough to get in their way.

Otherwise, it's a welcome display of silliness. We've done packed lines of spearmen and lizardmen riding dinosaurs, now it's time for burning chariots, thrones of blood, and frost maidens on war bears. This is asymmetric warfare in which every side is overpowered, the eight factions (four chaos gods, plus others such as Ogre Kingdoms and Grand Cathay) as disparate in their motivations as they are in the way they look.

There's one campaign objective—entering the realms of chaos in pursuit of the souls of demon princes, on the way to freeing an imprisoned bear-god, Ursun, though you can also win by wiping your enemies off the map—but this means marshaling an empire on the strategy map as much as it does guiding your armies on the battlefield.

And those battlefields are, thanks to the chaotic setting, some of the most imaginative we've yet seen. Each realm of chaos takes on the personality of its patron god, so Nurgle's is toxic and constantly wears your army down, Khorne's a simple plain where you battle hordes of demons, Slaanesh's a pink and purple series of hoops connected by portals, their god tempting you with gifts if you only turn around and go home. Tzeentch, the sorcery god, presents a maze of floating islands and a random route to the end. Following game after game set in moors and woodlands, with snowy mountaintops about the most unusual terrain feature, it's wonderful to see *Total War* let off the leash like this.

Your problem is that other factions are out there collecting demon princes' souls on their way to releasing the bear god too. Allow one to get too far down the path to

The armies of Nurgle are all green fumes and gaping maws.

Fire chariots and war bears... yeah, this all seems normal.

The trilogy goes out with a colorful and fantastical bang.

victory, and you'll be forced to head them off in a battle outside Ursun's prison. This will allow you an extra 15 turns to get into a better position. Accepting one of Slaanesh's gifts can be helpful too, though it means starting your trek through their realm again and costs you time. Then, on the strategy map, every 30 turns, portals open and spew chaos armies into the world that you'll have to mop up. This also costs you time.

Luckily, the diplomacy system has had an overhaul for this installment, and it's possible to make pacts with other factions for support, even if you know you're going to have to renege on the agreement later. It borrows some ideas from *Total War: Three Kingdoms*, in that you can make a quick deal and decide what another side can offer you more easily.

Outposts, though, are new for this game, allowing you to construct a fort in their territory and recruit troops from their lists, opening up a third set of recruitment slots that allows you to add new troops even if you were already maxed out. Making diplomacy easier, and tying it to your army in this way, makes it more likely you'll use it, reducing the number of border skirmishes but opening the way for you to take on armies your new allies are at war with, making battles off the main plot track feel more worthwhile.

Battles have had a shake-up too, with the final conflict in each of the chaos realms having more to do with Horde Mode or tower defense than with the classic *Total War* battles. It's great to see, but the realms of chaos can lack replayability once you've seen all they have to offer. Still, the *Warhammer* games have never lacked for DLC, and the Hitman-style merging of all three parts of the trilogy into one gigantic game should give plenty of replay value elsewhere for years to come.

So vast and unusual are some of the sights on offer in *Warhammer III* that we're surprised it performs as well as it does. The graphics have had an extra polish for this release, and we found our PC equipped with an RTX 3080 (10GB) card could manage around 40fps in 4K Ultra. Such are the requirements of keeping tabs on every unit and processing the AI of every faction that a fast CPU is required too, and this is going to be a 1080p game for many people, even those with 3080s who prefer a 60fps minimum. The recommended specs are relatively mild, however, which is great to see.

When the first *Total Warhammer* was released, we praised the way it brought tabletop wargaming to the PC in a way that made sense, as much as we loved squads of Space Marines running around in *Dawn of War* or *Battlesector*. Warhammer Fantasy has always been about massive armies clashing like the siege of Minas Tirith, and to see it realized is a big thrill. We could never have imagined what the third part of the trilogy would offer, and it goes out with a fantastical, imaginative, colorful bang. **–IAN EVENDEN**

VERDICT 8

Total War: WARHAMMER III

+ DEMONS Imaginative worlds of chaos; massed battles; strange temptations.

– LEMONS Sprawling size and limits to replay value can make it a slog.

RECOMMENDED SPECS CPU, Intel i5 / AMD Ryzen 5. RAM, 8GB. GPU: GTX 1660 / RX 5600XT.

$60, warhammer3.totalwar.com, Rated T for Teen

© SEGA

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Virus Scanner Slowdown
> Moore Fans
> Accessibility for All

Norton Your Nelly

In the January 2022 edition of *Maximum PC*, Edward posed a question in his letter titled "Hard drives and the theory of speed". To summarize, he was not reaching close to the stated speed of his drives. In his answer, Jeremy Laird stated that the issue was likely to be a hardware issue or some kind of configuration problem.

As a gray beard cyber-security consultant, I frequently see this type of complaint, and I believe you neglected one often culpable component: real-time anti-virus scanners. There was no mention of this in his letter, nor your response. Various brands do have better or worse performance than others here, but the reality is that the overhead caused by the real-time protection scanning each file as it is copied from the drive, and possibly again as it is written to the destination can seriously impact the real-world performance compared to the manufacturer's stated theoretical speed.

If you are copying from one drive to another within the same computer, there is little risk in disabling the real-time protection during the duplication/copy process. I have yet to see a malware variant that can self-instantiate by being copied. Different vendors may have different methods of disabling their real-time scanners, so no single process will work for everyone.

I would encourage Edward to first disable his real-time file protection (MS Defender, McAfee, SEP, SOPHOS, or whatever) and then re-run his copy process, and document the time versus his original attempt. I would be surprised if he did not realize a performance increase in this new attempt. **–E. Goldoff**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: Another reader going the extra mile to help other readers with their tech problems! Jeremy did a thorough job trying to help Edward in his original response, but as Mr. Goldoff points out, it's worth checking out software as well as hardware when it comes to these issues.

If you're having similar problems and want to see what's accessing your disks, press Ctrl + Shift + Esc to open up Windows Task Manager and click on the "Disk" column to sort processes by the amount they are accessing the drive. If you want to dig deeper, click on the Performance tab, and click Open Resource Monitor. From here, you can see what programs are accessing what drives, and which files they're accessing.

It's worth checking out just to see what Windows is doing in the background that could be slowing things down. It's not like the old days when you could hear a hard disk drive being accessed—the latest solid-state drives are almost silent!

Gimme Moore

Congratulations! Your March 2022 edition ($600 Budget Build) is definitely one to be proud of. As a long-time reader of *Maximum PC*, I cannot remember the last time I was so thrilled by the quality of articles. All were uniformly good, but I especially enjoyed the Moore's Law article and its many sidebars. Good luck to you and your staff. Looking forward to future editions. **–K. Oustalet**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: Thanks for all the lovely feedback this issue. On the March 2022 edition, I can't take all the credit – Jeremy Laird (who also wrote the Moore's Law feature) did such a phenomenal job with the handover on my first issue that I would have to have done something truly spectacular to mess it up!

Still, I'm glad that you enjoyed the issue, because like you say, it had some particularly enjoyable features for anyone into the future of the computing space. Last issue, we also looked back at the history of the internet, and these features seem to get great feedback from our readers.

Please let me know if there's anything else you'd particularly like to see in future issues of *Maximum PC* by emailing me at: editor@maximumpc.com. I love reading your feedback and try to respond to everything I can.

↘ submit your questions to: editor@maximumpc.com

Cool and the gang

Guy, I just want to say thanks to you and the staff for keeping the mags coming during a "changing of the guard". It's a nice surprise to go to the mailbox and get it early! Do you think you could do an in-depth article on AIO coolers relating to the size you need versus the CPU you have? I cut my teeth on the retro PC scene, so I'm not hip to the modern gear.

–T. Neumann

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: Our writer Sam and I are going to be doing more in the water cooling space by building some more "out there" builds, as well as helping anyone looking to build their first water-cooled system.

We're thinking more about custom loops at this stage, but AIO coolers will form some part of this, given how popular they are. Personally, I subscribe to the idea of using the largest grille that your case will support—if that's 360mm, then go for it, but if it's a compact build, then 240mm will usually suffice.

Just be aware that different 360mm radiators come in different sizes, as I found to my detriment when putting together my "Frankenstein" build in the last issue. The Raijintek EOS 360 RBW was a bit too big to fit into the Corsair 4000D case I was using, a fact I only realized after I'd unpacked all of the cooler equipment and emptied out the case.

Yes, even we admit to having made mistakes, but the difference is, we usually haven't bought the equipment and can easily use components in other builds. You don't want to buy the part and then find it won't fit, so always check the measurements.

Otherwise, don't be daunted, as it's dead easy to fit your own AIO cooler!

United Colors Of Maximum PC

I'm a long-time subscriber. Like many older people, distinguishing text in low-contrast situations is problematic. I was pleased to see in your first issue that green was the predominant accent color. In earlier issues, orange on gray was common and that was hard for me to read.

I note in the letters section, that black text is highlighted by orange, a reasonable presentation, whereas the low-contrast orange text on a gray background is difficult for me to read—it may not be a problem for you now, but wait a few decades! Best wishes for your success as Editor and for the continued excellence of the magazine.

–G. Gokel

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: I have somehow managed to make it to 40 with my eyesight intact, even though I work all day every day with computer screens. You are right Mr. Gokel, we need to do more to make the magazine as accessible as possible to all of our readers. I've spoken to our designer Fraser about this and we will do everything we can to bear this in mind for future editions.

Out Of Order

Many letters and columns in *Maximum PC* refer to back issues by the issue number. But I've scoured the magazine and can't find an issue number printed anywhere, just volume and number. How about putting a discrete issue number on the spine or the editorial page? Thanks! **–B. Patton**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: This letter wasn't the only one I received this month on this subject, and while it wasn't a problem to help these readers match up issue numbers with months and years, it's not something I want to be doing regularly!

So, now that you've had a peek behind the curtain at how we refer to the magazine internally—we do use numbers to refer to issues when making *Maximum PC* (this one is 203). However, when we publish, we use the month and year of publication, with a 13th "Holiday" edition each year, with no reference to the issue number.

To keep things simple, we'll keep this time-based issue referencing system going forward. Apologies to anyone who was left confused!

Linux hits and misses

Thanks for responding to, and publishing my email about gaming on Linux. It was an unexpected surprise and made me smile for half the day.

To answer your question, I consider gaming on Linux largely a miss rather than a hit. If you check out the list of games, they're old school—too many puzzles, copy-cat platformers of a certain plumber, or even half-decent versions of the original *Doom*. The variety of AAA titles for Linux, such as *Valheim*, doesn't appeal to me. Perhaps it is the genre or the poor performance on my relatively decent hardware, or maybe it's the way that I am forced to install and play these games, but it's why I'm not really excited about services such as Steam. That's just me, I suppose. I prefer being able to purchase a game and install it without the fuss and the drama.

I do have a Windows gaming computer for when I have time to play. I dislike the bloat and garbage that almost constantly wants to creep in and steal resources while I'm raiding with my *WoW* guild, or killing zombies that think I'm a running buffet.

I've always wanted game devs to support Linux as much as they do Apple or Windows—I've even had more than one email telling me to go away (not in those words) for asking whether their studio planned a Linux version of a game.

So, yes, the environment for supporting Linux gaming is in its infancy at best. The Steam handheld isn't something that I'm going to jump into just yet—I'd wait a while for a better chance of actually getting one if I go down that route. As for Proton, I remain skeptical that it will actually pan out. The way that everything exists at this time simply doesn't work for me. Besides, if I really want to play a game, I'm going to have to continue dealing with the hassles of Windows itself. No choice on that.

One article I'd love to see *Maximum PC* put into a future issue is how gamers with disabilities can optimize games for their unique challenges. I'm deaf, and sometimes it's frustrating. **–C. Rolfe**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: Thanks for your excellent letter and for highlighting another area where games have been lacking. Developers have taken great strides in making games more accessible for gamers with disabilities, from Microsoft's Xbox Adaptive Controller to Gears 5's colorblind mode, and *World of Warcraft*'s text-to-speech option.

However, it wasn't long ago that gamers had to suffer unreadable subtitles and no colorblind options at all, so there's more work to be done. I will discuss the idea with the team, and in the meantime, if there are any games you recommend for people with hearing impairments, let me know and I will feature them in a future issue. ⏻

THE BUILDS

THIS MONTH'S STREET PRICES...

BUDGET

WE'RE FINALLY BRINGING the budget AMD build up to the current generation, replacing the Ryzen 5 3600 with the 5600X—at a price increase of just $15. This should net us around 10-20 percent better performance, depending on the workload. Since this is the 'budget' machine, we're not upgrading to a more costly X570 motherboard, but sticking with the B550 chipset in Gigabyte's Aorus Elite AM4 mobo. Bear in mind you may need a 2000- or 3000-series Ryzen CPU to update the mobo BIOS if you buy a used or refurbished board.

We've adjusted the GPU used in the AMD system from a Radeon RX 6700 XT down to the 6600 XT (Sapphire's Nitro+ model) as it's a more appropriate card for a system targeting 1080p in games. It's joined by new memory from Kingston, the FURY Renegade 2x 8GB kit at 3600MHz. The same kit is also found in the Intel budget build.

We're going budget on our SSDs for both systems too, cutting down from 512GB to 500GB (barely noticeable for most users) but keeping PCIe 4.0 for speedy file transfers. The AMD system gets the new MSI Spatium M450, priced at a reasonable $60, while its Intel counterpart is using the T-Force Cardea Graphene Z44L from Team Group—on sale for $62, down from $70. Both machines are keeping the 4TB WD Blue for HDD secondary storage, which is holding steady at $60. If you're assembling one of these machines but don't think you'll need that much storage, consider nixing the hard drive and upgrading to a 1TB SSD instead.

Budget GPU prices appear to be stabilizing, with prices still high but merely $100 or so above their original RRPs rather than double them. As well as the 6600 XT in the AMD build, the Intel budget rig has a new graphics card: the Dual GeForce RTX 3050 from Asus, a solid wallet-friendly GPU costing $380, the lowest it's been in months. Don't forget our Intel system is currently using the Core i5-12400F as its CPU, which offers a lower price tag in exchange for a lack of integrated graphics, so a dedicated GPU is a must.

AMD INGREDIENTS

PART			PRICE	STREET PRICE
Case	Corsair 4000D Airflow		$85	
PSU	550W Corsair CV550 80+ Bronze		$41	
Mobo	Gigabyte B550 Aorus Elite AM4	NEW	$133	
CPU	AMD Ryzen 5 5600X	NEW	$229	
GPU	Sapphire Nitro+ Radeon RX 6600 XT 8GB	NEW	$379	$470
RAM	16GB (2 x 8GB) Kingston FURY Renegade CL16 @ 3600MHz	NEW	$93	
SSD	500GB MSI Spatium M450 PCIe 4.0 M.2 SSD	NEW	$60	
HDD	4TB WD Blue 5400 HDD		$60	
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)		$32	

Approximate Price: $1,112 / $1,203

INTEL INGREDIENTS

PART			PRICE	STREET PRICE
Case	Corsair 4000D Airflow		$85	
PSU	550W Corsair CV550 80+ Bronze		$41	
Mobo	ASRock B660 Pro RS		$120	
CPU	Intel Core i5-12400F		$180	
GPU	Asus Dual GeForce RTX 3050 8GB	NEW	$249	$380
RAM	16GB (2 x 8GB) Kingston FURY Renegade CL16 @ 3600MHz	NEW	$93	
SSD	500GB Team T-Force Cardea Graphene Z44L PCIe 4.0 M.2 SSD	NEW	$62	
HDD	4TB WD Blue 5400 HDD		$60	
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)		$32	

Approximate Price: $922 / $1,053

MID-RANGE

POWER SUPPLIES seem to be affordable this month, with last issue's EVGA SuperNOVA 750 GA down by over $10 and NZXT's C750 costing a sensible $88; both 80+ Gold rated for efficiency. Storage is also reasonable, with the top-notch 500GB Samsung 980 Pro on sale for $84 and the Corsair Force MP600 (from last issue's Intel system) down to just $78. Low prices prompted us to leave our drives alone, but the same can't be said for the AMD mid-range CPU. With our budget AMD PC upgrading to the Ryzen 5 5600X, we're upgrading to the Ryzen 7 5800X, which offers eight cores and 16 threads to the 5600X's six and 12. Multi-core speed is a lot faster, especially when overclocked. This adds over $100 onto the price, so if you're assembling a 1440p rig for games, consider sticking with the 5600X.

With a jump from Ryzen 5 to Ryzen 7, we opted to make a similar leap in the Intel machine. For a smaller price rise, we upgraded to the Core i7-12700F, aping the budget machine by choosing an F-series Intel CPU without integrated graphics. Processor performance is near-identical to the standard i7-12700, with eight hyperthreaded performance cores and four efficiency cores allowing for a total of 20 threads. Although the 5800X offers a higher base clock, overall performance from the 12700F is superior. The only downside is that Z690 motherboards are more pricey than their X570 equivalents.

While lower-end GPUs might be getting more affordable, powerful cards are still pretty expensive. The AMD machine keeps its MSI Gaming RX 6800 XT and its whopping 16GB of VRAM, while the Intel build has swapped over to the three-fan Asus TUF Gaming RTX 3070, which is one of the most affordable 3070 cards available at the time of writing. You'll also see that both systems have a new CPU cooler, the excellent H100i RGB Pro XT from Corsair, which is a steal at $72 and is compatible with both current-gen CPU sockets. Lastly, both systems are now benefiting from new memory in the form of the sleek Corsair Vengeance RGB RT.

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Lian Li PC-O11-Dynamic	$180	
PSU	750W NZXT C750 80+ Gold **NEW**	$88	
Mobo	ASRock X570 Phantom Gaming 4	$150	
CPU	AMD Ryzen 7 5800X **NEW**	$349	
Cooler	Corsair iCue H100i RGB Pro XT 240mm **NEW**	$72	
GPU	MSI Gaming Radeon RX 6800 XT 16 GB	$649	$1,130
RAM	16GB (2x 8GB) Corsair Vengeance RGB RT CL16 @ 3600MHz **NEW**	$105	
SSD	500GB Samsung 980 Pro NVME M.2 PCIe 4.0 SSD	$84	
HDD	4TB WD Blue 5400 HDD	$60	
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32	

Approximate Price: $1,769 / $2,250

INTEL INGREDIENTS

PART		PRICE	STREET PRICE
Case	Lian Li PC-O11-Dynamic	$180	
PSU	750W EVGA SuperNOVA 750 GA 80+ Gold	$92	
Mobo	ASUS Prime Z690-P LGA 1700	$212	
CPU	Intel Core i7-12700F **NEW**	$313	
Cooler	Corsair iCue H100i RGB Pro XT 240mm **NEW**	$72	
GPU	Asus TUF Gaming GeForce RTX 3070 8GB **NEW**	$499	$750
RAM	16GB (2x 8GB) Corsair Vengeance RGB RT CL16 @ 3600MHz **NEW**	$105	
SSD	500GB Corsair Force MP600 M.2 PCIe 4.0	$78	
HDD	4TB WD Blue 5400 HDD	$60	
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32	

Approximate Price: $1,643 / $1,894

TURBO
PHANTEKS

IT'S TIME TO GET SERIOUS and kick things up to the max for our turbo builds. While the Core i9-12900K is still a beast, there was room for improvement in the AMD build, so we've taken a step up from the Ryzen 9 5900X to the top-tier 5950X. Intel's chip is faster overall, but it's also a more recent release, so we'll have to wait for AMD's 6000 series of CPUs to see if Team Red can claw back ground at the high end. Meanwhile, the AMD system already had a flagship GPU (the RX 6900 XT, in this case, ASRock's Phantom Gaming D version), but the Intel system was sitting slightly below its maximum graphical potential with an RTX 3080 Ti. So, we've upgraded to an RTX 3090, specifically EVGA's FTW3 Ultra Gaming model, with a big juicy RGB strip and 24GB of VRAM. Of course, we'll probably be updating this again soon, since Nvidia announced the faster 3090 Ti at CES.

We decided to bump up the wattage of our Intel build a little, given that the GPU and CPU alone are capable of drawing more than 550W combined. To ensure a good amount of overclocking headroom, we've upgraded from a 750W capacity PSU to the Corsair RM850. The lower TDP of the Ryzen chip means we're sticking with Be Quiet!'s 750W Pure Power 11 FM in the AMD rig.

A $20 Newegg.com mail-in rebate on the WiFi-equipped version of Gigabyte's X570 Aorus Elite mobo saw us make the switch from its WiFi-less sibling, while we stuck with the MSI board in our Intel turbo system. Elsewhere, the Gigabyte SSD in the Intel machine was out of stock, so we swapped over to the 1TB FireCuda 530 from Seagate, on sale at $170. The Intel build also gets a new AIO cooler, the Asus ROG Strix LC II 360 ARGB, which matches the three fans of the AMD build's cooler and is currently on sale at $160.

Lastly, DDR5 memory is still prohibitively expensive, so we scoured the web to find the best-value 32GB kit to accompany that Core i9-12900K. Surprisingly, the Kingston FURY Beast kit we featured last month is seeing a massive sale, with almost $100 shaved off the RRP. If upgrading from DDR4 has been your to-do list, then snap this up now!

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$190	
PSU	750W Be Quiet! Pure Power 11 FM 80+ Gold	$115	
Mobo	Gigabyte X570 Aorus Elite WiFi **NEW**	$170	
CPU	AMD Ryzen 9 5950X **NEW**	$590	
Cooler	MSI MAG CoreLiquid 360R ARGB	$135	
GPU	ASRock Radeon RX 6900 XT Phantom Gaming D 16GB	$999	$1,300
RAM	32GB (2x 16GB) G.Skill Ripjaws V 32GB @ 4000MHz	$135	
SSD	Sabrent Rocket 4 Plus M.2 PCIe 4.0	$160	
HDD	6TB WD Blue 5400 HDD	$95	
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32	

Approximate Price: $2,621 / $2,922

INTEL INGREDIENTS

PART		PRICE	STREET PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$190	
PSU	850W Corsair RM850 80+ Gold **NEW**	$125	
Mobo	MSI PRO Z690-A WiFi LGA1700	$250	
CPU	Intel Core i9-12900K	$580	
Cooler	Asus ROG Strix LC II 360 ARGB **NEW**	$160	
GPU	EVGA GeForce RTX 3090 FTW3 Ultra Gaming 24GB **NEW**	$1,500	$1,920
RAM	32GB (2x 16GB) Kingston FURY Beast DDR5 @ 5200MHz	$255	
SSD	1TB Seagate FireCuda 530 M.2 PCIe 4.0 SSD **NEW**	$170	
HDD	6TB WD Blue 5400 HDD	$95	
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32	

Approximate Price: £3,357 / $3,777

Maximum PC (ISSN 1522-4279) is published 13 times a year, monthly plus a Holiday issue following the December issue, by Future US, Inc., 10th floor, 1100 13th Street, N.W Washington DC 20005, USA. Website: www.futureus.com. Periodicals postage paid at New York, NY, and at additional mailing offices. Newsstand distribution is handled by Curtis Circulation Company. Basic subscription rates: one year (13 issues) US: $30; Canada: US$30; Foreign: US$50. Canadian and foreign orders must be prepaid. Canadian price includes postage and GST (GST #R128220688). PMA #40612608. Subscriptions do not include newsstand specials. POSTMASTER: Send changes of address to *Maximum PC*, PO Box 2024, Langhorne, PA 19047, USA. Future US, Inc. also publishes *MacLife*, and *PC Gamer*.

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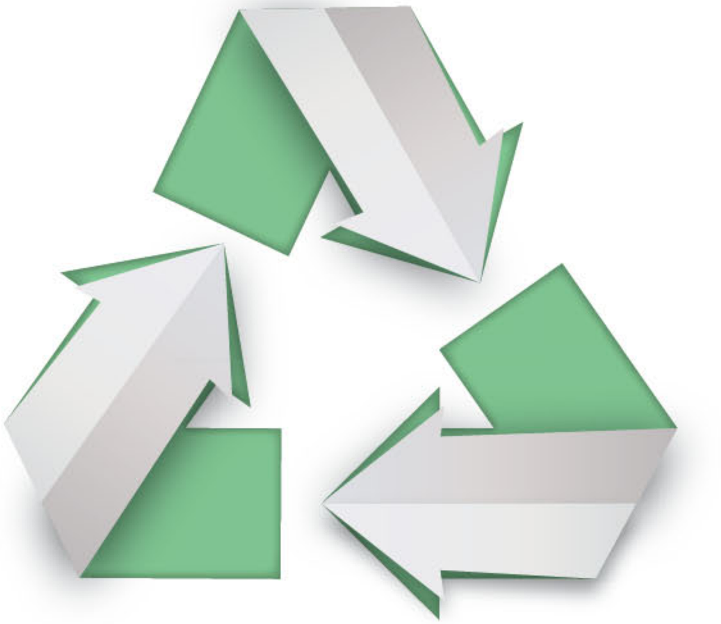

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